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Heart Disease and Stroke Statistics—2016 Update

A Report From the American Heart Association

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Summary

Each year, the American Heart Association (AHA), in conjunction with the Centers for Disease Control and Prevention, the National Institutes of Health, and other government agencies, brings together the most up-to-date statistics related to heart disease, stroke, and other cardiovascular and metabolic diseases and presents them in its Heart Disease and Stroke Statistical Update. The Statistical Update represents a critical resource for the lay public, policy makers, media professionals, clinicians, healthcare administrators, researchers, and others seeking the best available data on these conditions. Together, cardiovascular disease (CVD) and stroke produce immense health and economic burdens in the United States and globally. The Statistical Update brings together in a single document up-to-date information on the core health behaviors (including diet, physical activity [PA], smoking, and energy balance) and health factors (including blood pressure, cholesterol, and glucose) that define cardiovascular health; a range of major clinical disease conditions (including stroke, congenital heart disease, rhythm disorders, subclinical atherosclerosis, coronary heart disease, heart failure, valvular disease, and peripheral arterial disease); and the associated outcomes (including quality of care, procedures, and economic costs). Since 2006, the annual versions of the Statistical Update have been cited >28 000 times in the literature. In 2014 alone, the various Statistical Updates were cited >5000 times.

Each annual version of the Statistical Update undergoes major revisions to include the newest nationally representative data, add additional relevant published scientific findings, remove older information, add new sections or chapters, and increase the number of ways to access and use the assembled information. This year-long process, which begins as soon as the previous Statistical Update is published, is performed by the AHA Statistics Committee faculty volunteers and staff. For example, this year's edition includes new data on the monitoring and benefits of cardiovascular health in the population, new metrics to assess and monitor healthy diets, additional information in many chapters on the global CVD and stroke burden, new information on stroke in young adults, a new focus on underserved and minority populations, and further evidence-based approaches to changing behaviors, implementation strategies, and implications of the AHA's 2020 Impact Goals. Below are a few highlights from this year's Update.

Current Status of Cardiovascular Health in the United States (Chapter 2)

- The concept of cardiovascular health represents a heightened focus for the AHA, with 3 central and novel emphases:
  - —An expanded focus on not only CVD prevention but also promotion of positive cardiovascular health, in addition to the treatment of established CVD
  - —The prioritization of both health behaviors (healthy diet pattern, appropriate energy balance, PA, and nonsmoking) and health factors (optimal blood lipids, blood pressure, glucose levels) throughout the lifespan as primary goals unto themselves
  - —Population-level health promotion strategies to shift the majority of the public toward greater cardiovascular health, in addition to targeting those individuals at greatest CVD risk, because CVD occurs at all risk levels across the population and because healthy lifestyles are uncommon throughout the US population
- Among children, the prevalence of ideal levels of cardiovascular health behaviors and factors currently varies from <1% for the healthy diet pattern to >80% for the smoking, blood pressure, and fasting glucose metrics.
- Among US adults, the prevalence of ideal levels of cardiovascular health behaviors and factors currently varies from about 1.5% for the healthy diet pattern to up to 78% for the smoking metric (never having smoked or being a former smoker who has quit for >12 months).
- Fewer children over time are meeting the ideal body mass index metric, whereas more are meeting the ideal smoking and total cholesterol metrics. Other metrics do not show consistent trends over time in children.
- More adults over time are meeting the smoking metric, whereas fewer are meeting the body mass index and glucose metrics. Trends for other metrics are not evident over time in adults.

Effective Approaches to Improve Cardiovascular Health (Chapter 2)

- The current evidence supports a range of complementary strategies to improve cardiovascular health, including the following:
  - —Individual-focused approaches, which target lifestyle and treatments at the individual level
  - —Healthcare systems approaches, which encourage, facilitate, and reward efforts by providers and patients to improve health behaviors and health factors
  - —Population approaches, which target lifestyle and treatments in schools or workplaces, local communities, and states, as well as throughout the nation
- Such approaches can focus on both (1) improving cardiovascular health among those who currently have less than optimal levels and (2) preserving cardiovascular health among those who currently have ideal levels (in particular, children, adolescents, and young adults) as they age.
- The metrics with the greatest potential for improvement are health behaviors, including diet quality, PA, and body weight. However, each of the cardiovascular health metrics can be improved and deserves major focus.

Health Behaviors (Chapters 3 to 6)

Based on comparable risk assessment methods, poor lifestyle behaviors and lifestyle-related risk factors are the foremost causes of death and disability in the United States and in the world.

Smoking/Tobacco Use (Chapter 3)

- Although tobacco use has declined substantially in the United States, it remains the second-leading cause of total deaths and disability. The percentage of adults who reported current cigarette use declined from 24.1% in 1998 to 16.9% in 2014; among high school students, the decline was from 36.4% in 1997 to 5.6% in 2013. Still, almost one third of coronary heart disease deaths are attributable to smoking and exposure to secondhand smoke.
- Declines in tobacco usage in the United States may be threatened by the >450 e-cigarette products that were available in 2014. To date, the risks and benefits of e-tobacco products remain controversial but are an area of intense investigation by scientists, as well as scrutiny by the US Food and Drug Administration. Public health experts are concerned that although e-cigarettes are thought to have a lower risk of harmful effects than conventional cigarettes, they may be a gateway to smoking traditional cigarettes or may promote relapse among former smokers, which could erode gains in the public's awareness of the harms of tobacco products.
- Cigarette smoking is associated with 9% of annual aggregated healthcare spending in the United States. Annual smoking-attributable economic costs in the United States, including direct medical costs and lost productivity, are estimated to exceed $289 billion.

Physical Inactivity (Chapter 4)

- In 2013, 15.2% of adolescents reported being inactive during the prior week, and inactivity was more likely to be reported by girls (19.2%) than boys (11.2%). Inactivity was more commonly reported by black (27.3%) and Hispanic (20.3%) girls than their white counterparts (16.1%); similarly, black (15.2%) and Hispanic (12.1%) boys reported more inactivity than white boys (9.2%).
- According to 2014 National Health Interview Survey data, only half of American adults met the current aerobic PA guidelines (≥150 minutes of moderate PA or 75 minutes of vigorous PA or an equivalent combination each week). Women (47.0%) were less likely to meet the guidelines than men (53.2%), and non-Hispanic blacks (43.5%) and Hispanics (41.3%) were less likely to meet them than non-Hispanic whites (53.5%).
- Unfortunately, the proportion of individuals meeting PA recommendations is likely to be lower than indicated by self-report data. Studies examining actual (with accelerometers, pedometers, etc) versus self-reported PA indicate that both men and women overestimate their PA substantially (by 44% and 138% for men and women, respectively).

Nutrition (Chapter 5)

- The leading risk factor for death and disability in the United States is suboptimal diet quality, which in 2010 led to 678 000 annual deaths attributable to all causes. Major contributors were insufficient intakes of fruits, nuts/seeds, whole grains, vegetables, and seafood, as well as excess intakes of sodium. In the United States, an estimated 58 000 annual CVD deaths in 2010 were attributable to sodium intake >2.0 g/d, representing 1 in 16 (6.3%) of all CVD deaths and 1 in 8 (13.1%) CVD deaths before age 70 years. Globally, an estimated 1.65 million annual CVD deaths were attributable to sodium intake >2.0 g/d, representing nearly 1 in 10 (9.5%) of all CVD deaths.
- Between 2003 and 2012, certain aspects of diet quality improved in the United States, including increases in whole grains and reductions in sugar-sweetened beverages. The prevalence of both children and adults meeting the dietary goals improved between 2003 to 2004 and 2011 to 2012. The prevalence of ideal levels of diet (healthy diet score >80) increased from 0.2% to 0.6% in children and from 0.7% to 1.5% in adults. During this period, the proportion of youths aged 5 to 19 years with poor scores on the dietary metric for cardiovascular health decreased steadily from 69.2% to 54.6%, whereas for adults, the decrease was from 50.3% to 41.0%.
- Although healthier diets cost modestly more than unhealthful diets, comparing extremes of unhealthful versus healthful food-based diet patterns, the more healthful patterns cost on average ≈$1.50 per day more. Similarly priced options are also common; in a comparison of 20 fruits and vegetables versus 20 common snack foods such as cookies, chips, pastries, and crackers, the average price per portion of fruits and vegetables was 31 cents, with an average of 57 calories per portion, versus 33 cents and 183 calories per portion for snack foods.

Obesity (Chapter 6)

- Although the overall prevalence of obesity in US youth did not change between 2003 to 2004 and 2011 to 2012, the prevalence decreased among those aged 2 to 5 years. Obesity decreased among those of higher socioeconomic status but increased among those of lower socioeconomic status. In addition, the overall prevalence of severe obesity in US youth continued to increase, especially among adolescent boys.
- Overweight and obesity predispose individuals to most major risk factors, including physical inactivity, hypertension, hyperlipidemia, and diabetes mellitus.
- Excess body weight is among the leading causes of death and disability in the United States and globally, with burdens expected to increase in coming years.
- Among overweight and obese individuals, existing cardiometabolic risk factors should be monitored and treated intensively with diet quality, PA, and pharmacological or other treatments as necessary. Each of these interventions provides benefits independent of weight loss and maintenance.
- Estimated mean annual per capita healthcare expenses attributable to obesity are $1160 for men and $1525 for women.

Health Factors (Chapters 7 to 12)

The prevalence and control of cardiovascular health factors remains a major issue for many Americans.

Family History and Genetics (Chapter 7)

- Familial aggregation of CVD is related to clustering of specific lifestyle and other risk factors, each of which

has environmental and genetic contributors. Patients with a family history of coronary artery disease have a higher prevalence of traditional CVD risk factors, underscoring opportunities for prevention.
- The risk of most CVD conditions is higher in the presence of a family history, including CVD (45% higher odds with sibling history), stroke (50% higher odds with history in a first-degree relative), atrial fibrillation (AF; 80% higher odds with parental history), heart failure (70% higher odds with parental history), and peripheral arterial disease (80% higher odds with family history). This excess risk reflects genetic, epigenetic, and shared behavioral and environmental risk factors.

High Blood Cholesterol and Other Lipids (Chapter 8)

- 75.7% of children and 46.6% of adults have ideal cholesterol levels (untreated total cholesterol <170 mg/dL for children and <200 mg/dL for adults). Prevalence of ideal levels has improved over the past decade in children but remained the same in adults.
- According to 2009 to 2012 data, >100 million US adults ≥20 years of age have total cholesterol levels ≥200 mg/dL; almost 31 million have levels ≥240 mg/dL.
- During 2003 to 2012, the percentage of adults aged ≥40 years who had used a cholesterol-lowering medication in the past 30 days increased from 20% to 28%.

High Blood Pressure (Chapter 9)

- Based on 2009 to 2012 data, 32.6% of US adults ≥20 years of age have hypertension, which represents ≈80.0 million US adults. African American adults have among the highest prevalence of hypertension in the world. Among non-Hispanic black men and women, the age-adjusted prevalence of hypertension was 44.9% and 46.1%, respectively.
- National Health and Nutrition Examination Survey (NHANES) data from 2009 to 2012 revealed that among US adults with hypertension, 54.1% were controlled, 76.5% were currently treated, 82.7% were aware they had hypertension, and 17.3% were undiagnosed.
- From 2003 to 2013, the death rate attributable to high blood pressure increased 8.2%, and the actual number of deaths rose 34.7% (National Heart, Lung, and Blood Institute tabulation). During this 10-year period, the corresponding values were a 14.4% and 30.9% increase in non-Hispanic whites; a 1.7% and 75.5% increase in Hispanics; and a 9.1% decrease and 18.4% increase in non-Hispanic blacks.

Diabetes Mellitus (Chapter 10)

- Diabetes mellitus affects 1 in 10 US adults, with 90% to 95% of cases being type 2 diabetes mellitus. Diabetes mellitus disproportionately affects racial/ethnic minorities. Type 2 diabetes mellitus is increasingly common in children and adolescents; the disease historically was diagnosed primarily in adults ≥40 years of age. The prevalence of type 2 diabetes mellitus in children/adolescents has increased by 30.5% between 2001 and 2009, and it now constitutes ≈50% of all childhood diabetes mellitus.
- Diabetes mellitus is associated with reduced longevity; men and women with diabetes mellitus live an average of 7.5 and 8.2 years less, respectively, than their counterparts without diabetes mellitus.

Metabolic Syndrome (Chapter 11)

- From 1999 to 2010, the age-adjusted national prevalence of metabolic syndrome in the United States peaked (in 2001–2002) and began to fall. This is attributable to decreases in the age-adjusted prevalence among women and no change in men. In addition, there has been variation in the trends over time for each individual component of the metabolic syndrome. Generally, the national prevalences of hypertriglyceridemia and elevated blood pressure have decreased, whereas hyperglycemia and elevated waist circumference have increased. However, these trends also vary significantly by sex and race/ethnicity.
- Perhaps most importantly with respect to meeting the 2020 goals, the prevalence of metabolic syndrome increases with greater cumulative life-course exposure to sedentary behavior and physical inactivity; screen time, including television viewing; fast food intake; short sleep duration; and intake of sugar-sweetened beverages. Each of these risk factors is reversible with lifestyle change.

Cardiovascular Conditions/Diseases (Chapters 13 to 22)

Rates of death attributable to CVD have declined in the United States, but the burden remains high.

Total Cardiovascular Diseases (Chapter 13)

- The 2013 overall rate of death attributable to CVD was 222.9 per 100 000 Americans. The death rates were 269.8 for males and 184.8 for females. The rates were 270.6 for non-Hispanic white males, 356.7 for non-Hispanic black males, 197.4 for Hispanic males, 183.8 for non-Hispanic white females, 246.6 for non-Hispanic black females, and 136.4 for Hispanic females.
- From 2003 to 2013, death rates attributable to CVD declined 28.8%. In the same 10-year period, the actual number of CVD deaths per year declined by 11.7%. Yet in 2013, CVD still accounted for 30.8% (800 937) of all 2 596 993 deaths, or ≈1 of every 3 deaths in the United States.
- On the basis of 2013 death rate data, >2200 Americans die of CVD each day, an average of 1 death every 40 seconds. Approximately 155 000 Americans who died of CVD in 2013 were <65 years of age. In 2013, 35% of deaths attributable to CVD occurred before the age of 75 years, which is younger than the current average life expectancy of 78.8 years.
- For the first time since 1983, more males (402 851) died of CVD than females (398 086).

Stroke (Chapter 14)

- In 2013, stroke fell from the fourth to the fifth leading cause of death in the United States, behind diseases of the heart, cancer, chronic lower respiratory diseases, and unintentional injury.
- From 2003 to 2013, the relative rate of stroke death fell by 33.7% and the actual number of stroke deaths declined

by 18.2%. Yet each year, ≈795 000 people continue to experience a new or recurrent stroke (ischemic or hemorrhagic). Approximately 610 000 of these are first events and 185 000 are recurrent stroke events. In 2013, stroke caused ≈1 of every 20 deaths in the United States. On average, every 40 seconds, someone in the United States has a stroke, and someone dies of one approximately every 4 minutes.

- The decline in stroke mortality over the past decades, a major improvement in population health observed for both sexes and all race and age groups, has resulted from reduced stroke incidence and lower case fatality rates. The significant improvements in stroke outcomes are concurrent with cardiovascular risk factor control interventions. The hypertension control efforts initiated in the 1970s appear to have had the most substantial influence on the accelerated decline in stroke mortality, with lower blood pressure distributions in the population. Control of diabetes mellitus and high cholesterol and smoking cessation programs, particularly in combination with hypertension treatment, also appear to have contributed to the decline in stroke mortality.
- Approximately 10% of all strokes occur in people 18 to 50 years of age. Between 1995 and 2008, National Health Interview Survey data reveal that hospitalizations for ischemic stroke increased among adolescents and young adults (aged 5–44 years), whereas subarachnoid hemorrhage hospitalizations decreased during that same time period.
- Stroke death rates declined more among people aged ≥65 years (–54.1%; from 534.1 to 245.2 per 100 000) than among those aged 45 to 64 years (–53.6%; from 43.5 to 20.2 per 100 000) or those aged 18 to 44 years (–45.9%; from 3.7 to 2.0 per 100 000).

Atrial Fibrillation (Chapter 16)

- Multiple lines of evidence have increased awareness of the burden of unrecognized AF. In individuals without a history of AF with recent pacemaker or defibrillator implantation, subclinical atrial tachyarrhythmias were detected in 10.1% of patients. Subclinical atrial tachyarrhythmias were associated with a 5.6-fold higher risk of clinical AF and ≈13% of ischemic strokes or embolism. A recent systematic review suggested that one needs to screen 170 community-based individuals at least 65 years of age to detect 1 case of AF.
- In the Framingham Heart Study, there have been striking temporal trends in the epidemiology of AF documented over 50 years. The age-adjusted incidence and prevalence of AF in the white participants increased ≈4-fold, yet the multivariable adjusted hazard of stroke (74%) and death (25%) associated with AF declined over the same time period. Less is known about the epidemiology of AF over time in ethnic/racial minorities.
- Secondary analyses of observational and randomized data generally support benefits of risk factor modification for primary prevention of AF. There is also growing evidence supporting the value of risk factor reduction, particularly weight management and exercise, in secondary prevention of AF recurrences and symptoms.

Sudden Cardiac Arrest (Chapter 17)

- Each year, ≈356 500 people experienced emergency medical services–assessed out-of-hospital cardiac arrests in the United States. Survival to hospital discharge after nontraumatic emergency medical services–treated cardiac arrest with any first recorded rhythm was 12.0% for patients of any age. Of the ≈22 520 bystander-witnessed out-of-hospital cardiac arrests in 2014–2015, 38.6% of victims survived to hospital discharge.
- Each year, ≈209 000 people are treated for in-hospital cardiac arrest.

Subclinical Atherosclerosis (Chapter 18) and Coronary Heart Disease (Chapter 19)

- CAC was noted as highly predictive of CHD event risk across all age groups, suggesting that once CAC is known, chronological age has less importance. Compared with a CAC score of 0, CAC >100 imparted an increased multivariable-adjusted CHD event risk in younger individuals (45-54 years old) with an HR of 12.4. The respective risk was similar even in the very elderly (75-84 years of age) with an HR of 12.1.
- Coronary heart disease alone caused ≈1 of every 7 deaths in the United States in 2013. In 2013, 370 213 Americans died of coronary heart disease. Each year, an estimated ≈660 000 Americans have a new coronary attack (defined as first hospitalized myocardial infarction or coronary heart disease death) and ≈305 000 have a recurrent attack. It is estimated that an additional 160 000 silent myocardial infarctions occur each year. Approximately every 34 seconds, 1 American has a coronary event, and approximately every 1 minute 24 seconds, an American will die of one.

Heart Failure (Chapter 20)

- In 2013, 1 in 9 death certificates (284 388 deaths) in the United States mentioned heart failure. Heart failure was the underlying cause in 58 309 of those deaths. The number of any-mention deaths attributable to heart failure was approximately as high in 1995 (287 000) as it was in 2013 (284 000). Additionally, hospital discharges for heart failure remained stable from 2000 to 2010, with first-listed discharges of 1 008 000 and 1 023 000, respectively.
- Mortality declines in heart failure have been documented, likely related to evidence-based approaches to treat heart failure risk factors and to implementation of angiotensin-converting enzyme inhibitors, β-blockers, coronary revascularization, implantable cardioverter-defibrillators, and cardiac resynchronization therapeutic strategies.

Valvular, Venous, and Aortic Diseases (Chapter 21) and Peripheral Artery Disease (Chapter 22)

- Data suggest that the prevalence of any valve disease is 2.5%, with no difference between men and women.
- In 2013, 50 222 deaths were related to valvular HD. Of those, 67.5% were due to aortic valve disorders.
- PAD affects ≈8.5 million Americans aged ≥40 years and is associated with significant morbidity and mortality.
- In 2013, PAD any-mention mortality was 61 097. PAD was the underlying cause in 13 639 of those deaths.

- The risk factors for PAD are similar but not identical to those for CHD. DM and cigarette smoking are stronger risk factors for PAD than for CHD. Most studies suggest that the prevalence of PAD is similar in men and women. Metabolic syndrome in older persons (driven most prominently by the HBP component) and elevated inflammation markers are also risk factors.

Cardiovascular Quality of Care, Procedure Utilization, and Costs (Chapters 23 to 25)

The Statistical Update provides critical data in several sections on the magnitude of healthcare delivery and costs, as well as the quality of healthcare delivery, related to CVD risk factors and conditions.

Quality-of-Care Metrics for CVD (Chapter 23)

- The Institute of Medicine has identified 6 domains of quality of care, including safety, effectiveness, patient-centered care, timely care, efficiency, and equitable care.
- According to the Medicare Patient Safety Monitoring System, between 2005 and 2011, adverse event rates in hospitalized patients declined for both myocardial infarction (from 5.0% to 3.7%) and congestive heart failure (from 3.7% to 2.7%)
- However, in the Practice Innovation and Clinical Excellence (PINNACLE) outpatient registry, only 66.5% of eligible patients with coronary artery disease received the optimal evidence-based combination of medications.
- A randomized trial of post–acute coronary care syndrome that used multiple modalities to enhance adherence to 4 indicated medications (clopidogrel, statins, angiotensin-converting enzyme inhibitors/angiotensin receptor blockers, and β-blockers) demonstrated better adherence in the intervention group (89.3% versus 73.9%) at 1 year.
- A recent study from a Veterans Health Administration national cohort of CVD patients showed that women with CVD were less likely than men to receive statins (57.6% versus 64.8%) or high-intensity statins (21.1% versus 23.6%) as recommended in the 2013 American College of Cardiology/AHA cholesterol management guidelines. The authors concluded that although women with CVD are less likely to receive evidence-based statin and high-intensity statins than men, their use remains low in both sexes.
- Similar or larger challenges persist in the outpatient setting in discussion and counseling for PA and dietary habits.

Cardiovascular Procedure Use and Costs (Chapters 24 and 25)

- The total number of inpatient cardiovascular operations and procedures increased 28% between 2000 and 2010, from 5 939 000 to 7 588 000.
- Data on Medicare beneficiaries undergoing a coronary revascularization procedure between 2008 and 2012 indicate that the rapid growth in nonadmission percutaneous coronary interventions (from 60 405 to 106 495) has been more than offset by the decrease in percutaneous coronary intervention admissions (from 363 384 to 295 434).
- According to the 2012 National Healthcare Cost and Utilization Project statistics, the mean hospital charge for a vascular or cardiac surgery or procedure in 2012 was $78 897: cardiac revascularization cost $149 480, and percutaneous interventions cost ≈$70 027.
- For 2011 to 2012, the estimated annual costs for CVD and stroke were $316.6 billion, including $193.1 billion in direct costs (hospital services, physicians and other professionals, prescribed medications, home health care, and other medical durables) and $123.5 billion in indirect costs from lost future productivity (cardiovascular and stroke premature deaths). CVD costs more than any other diagnostic group.
- By comparison, in 2011, the estimated direct cost of all cancer was $88.7 billion (50% for outpatient or doctor office visits, 35% for inpatient care, and 11% for prescription drugs).

Conclusions

The AHA, through its Statistics Committee, continuously monitors and evaluates sources of data on heart disease and stroke in the United States to provide the most current information available in the Statistical Update. This annual Statistical Update is the product of a full year's worth of effort by dedicated volunteer physicians and scientists, committed government professionals, and outstanding AHA staff members, without whom publication of this valuable resource would be impossible. Their contributions are gratefully acknowledged.

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Note: Population data used in the compilation of NHANES prevalence estimates are for the latest year of the NHANES survey being used. Extrapolations for NHANES prevalence estimates are based on the census resident population for 2012 because this is the most recent year of NHANES data used in the Statistical Update.

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*Modest.

†Significant.

1. About These Statistics

The AHA works with the CDC's NCHS, the NHLBI, the NINDS, and other government agencies to derive the annual statistics in this Heart Disease and Stroke Statistical Update. This chapter describes the most important sources and the types of data we use from them. For more details, see Chapter 27 of this document, the Glossary.

The surveys used are the following:

- BRFSS—ongoing telephone health survey system
- GCNKSS—stroke incidence rates and outcomes within a biracial population
- MEPS—data on specific health services that Americans use, how frequently they use them, the cost of these services, and how the costs are paid
- NHANES—disease and risk factor prevalence and nutrition statistics
- NHIS—disease and risk factor prevalence
- NHDS—hospital inpatient discharges and procedures (discharged alive, dead, or status unknown)
- NAMCS—physician office visits
- NHHCS—staff, services, and patients of home health and hospice agencies
- NHAMCS—hospital outpatient and ED visits
- Nationwide Inpatient Sample of the AHRQ—hospital inpatient discharges, procedures, and charges
- NNHS—nursing home residents
- National Vital Statistics System—national and state mortality data
- WHO—mortality rates by country
- YRBSS—health-risk behaviors in youth and young adults

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Abbreviations Used in Chapter 1

AHA	American Heart Association
AHRQ	Agency for Healthcare Research and Quality
AP	angina pectoris
ARIC	Atherosclerosis Risk in Communities Study
BP	blood pressure
BRFSS	Behavioral Risk Factor Surveillance System
CDC	Centers for Disease Control and Prevention
CHS	Cardiovascular Health Study
CVD	cardiovascular disease
DM	diabetes mellitus
ED	emergency department
FHS	Framingham Heart Study
GCNKSS	Greater Cincinnati/Northern Kentucky Stroke Study
HD	heart disease
HF	heart failure
ICD	*International Classification of Diseases*
ICD-9-CM	*International Classification of Diseases, Clinical Modification, 9th Revision*
ICD-10	*International Classification of Diseases, 10th Revision*
MEPS	Medical Expenditure Panel Survey
MI	myocardial infarction
NAMCS	National Ambulatory Medical Care Survey
NCHS	National Center for Health Statistics
NHAMCS	National Hospital Ambulatory Medical Care Survey
NHANES	National Health and Nutrition Examination Survey
NHDS	National Hospital Discharge Survey
NHHCS	National Home and Hospice Care Survey
NHIS	National Health Interview Survey
NHLBI	National Heart, Lung, and Blood Institute
NINDS	National Institute of Neurological Disorders and Stroke
NNHS	National Nursing Home Survey
PAD	peripheral artery disease
WHO	World Health Organization
YRBSS	Youth Risk Behavior Surveillance System

See Glossary (Chapter 27) for explanation of terms.

Disease Prevalence

Prevalence is an estimate of how many people have a disease at a given point or period in time. The NCHS conducts health examination and health interview surveys that provide estimates of the prevalence of diseases and risk factors. In this Update, the health interview part of the NHANES is used for the prevalence of CVDs. NHANES is used more than the NHIS because in NHANES, AP is based on the Rose Questionnaire; estimates are made regularly for HF; hypertension is based on BP measurements and interviews; and an estimate can be made for total CVD, including MI, AP, HF, stroke, and hypertension.

A major emphasis of this Statistical Update is to present the latest estimates of the number of people in the United States who have specific conditions to provide a realistic estimate of burden. Most estimates based on NHANES prevalence rates are based on data collected from 2009 to 2012 (in most cases, these are the latest published figures). These are applied to census population estimates for 2012. Differences in population estimates cannot be used to evaluate possible trends in prevalence because these estimates are based on extrapolations of rates beyond the data collection period by use of more recent census population estimates. Trends can only be evaluated by comparing prevalence rates estimated from surveys conducted in different years.

Risk Factor Prevalence

The NHANES 2009 to 2012 data are used in this Update to present estimates of the percentage of people with high lipid values, DM, overweight, and obesity. The NHIS is used for the prevalence of cigarette smoking and physical inactivity. Data for students in grades 9 through 12 are obtained from the YRBSS.

Incidence and Recurrent Attacks

An incidence rate refers to the number of new cases of a disease that develop in a population per unit of time. The unit of time for incidence is not necessarily 1 year, although we often discuss incidence in terms of 1 year. For some statistics, new and recurrent attacks or cases are combined. Our national incidence estimates for the various types of CVD are extrapolations to the US population from the FHS, the ARIC

study, and the CHS, all conducted by the NHLBI, as well as the GCNKSS, which is funded by the NINDS. The rates change only when new data are available; they are not computed annually. Do not compare the incidence or the rates with those in past editions of the Heart Disease and Stroke Statistics Update (also known as the Heart and Stroke Statistical Update for editions before 2005). Doing so can lead to serious misinterpretation of time trends.

Mortality

Mortality data are generally presented according to the underlying cause of death. "Any-mention" mortality means that the condition was nominally selected as the underlying cause or was otherwise mentioned on the death certificate. For many deaths classified as attributable to CVD, selection of the single most likely underlying cause can be difficult when several major comorbidities are present, as is often the case in the elderly population. It is useful, therefore, to know the extent of mortality attributable to a given cause regardless of whether it is the underlying cause or a contributing cause (ie, its "any-mention" status). The number of deaths in 2013 with any mention of specific causes of death was tabulated by the NHLBI from the NCHS public-use electronic files on mortality.

The first set of statistics for each disease in this Update includes the number of deaths for which the disease is the underlying cause. Two exceptions are Chapter 9 (High Blood Pressure) and Chapter 20 (Cardiomyopathy and Heart Failure). High BP, or hypertension, increases the mortality risks of CVD and other diseases, and HF should be selected as an underlying cause only when the true underlying cause is not known. In this Update, hypertension and HF death rates are presented in 2 ways: (1) As nominally classified as the underlying cause and (2) as any-mention mortality.

National and state mortality data presented according to the underlying cause of death were computed from the mortality tables of the NCHS World Wide Web site or the CDC compressed mortality file. Any-mention numbers of deaths were tabulated from the electronic mortality files of the NCHS World Wide Web site.

Population Estimates

In this publication, we have used national population estimates from the US Census Bureau for 2012 in the computation of morbidity data. NCHS population estimates for 2013 were used in the computation of death rate data. The Census Bureau World Wide Web site[1] contains these data, as well as information on the file layout.

Hospital Discharges and Ambulatory Care Visits

Estimates of the numbers of hospital discharges and numbers of procedures performed are for inpatients discharged from short-stay hospitals. Discharges include those discharged alive, dead, or with unknown status. Unless otherwise specified, discharges are listed according to the first-listed (primary) diagnosis, and procedures are listed according to all listed procedures (primary plus secondary). These estimates are from the NHDS of the NCHS unless otherwise noted. Ambulatory care visit data include patient visits to physician offices and hospital outpatient departments and EDs. Ambulatory care visit data reflect the first-listed (primary) diagnosis. These estimates are from the NAMCS and NHAMCS of the NCHS. Data for community health centers, which were included in estimates in previous years, were not available for 2012 NAMCS estimates included in this Update.

International Classification of Diseases

Morbidity (illness) and mortality (death) data in the United States have a standard classification system: the *ICD*. Approximately every 10 to 20 years, the *ICD* codes are revised to reflect changes over time in medical technology, diagnosis, or terminology. Where necessary for comparability of mortality trends across the 9th and 10th *ICD* revisions, comparability ratios computed by the NCHS are applied as noted.[2] Effective with mortality data for 1999, we are using the 10th revision (*ICD-10*). It will be a few more years before the 10th revision is systematically used for hospital discharge data and ambulatory care visit data, which are based on *ICD-9-CM*.[3]

Age Adjustment

Prevalence and mortality estimates for the United States or individual states comparing demographic groups or estimates over time either are age specific or are age adjusted to the 2000 standard population by the direct method.[4] International mortality data are age adjusted to the European standard.[5] Unless otherwise stated, all death rates in this publication are age adjusted and are deaths per 100 000 population.

Data Years for National Estimates

In this Update, we estimate the annual number of new (incidence) and recurrent cases of a disease in the United States by extrapolating to the US population in 2011 from rates reported in a community- or hospital-based study or multiple studies. Age-adjusted incidence rates by sex and race are also given in this report as observed in the study or studies. For US mortality, most numbers and rates are for 2013. For disease and risk factor prevalence, most rates in this report are calculated from the 2009 to 2012 NHANES. Because NHANES is conducted only in the noninstitutionalized population, we extrapolated the rates to the total US population in 2012, recognizing that this probably underestimates the total prevalence, given the relatively high prevalence in the institutionalized population. The numbers and rates of hospital inpatient discharges for the United States are for 2010. Numbers of visits to physician offices, hospital EDs, and hospital outpatient departments are for 2012. Except as noted, economic cost estimates are for 2011 to 2012.

Cardiovascular Disease

For data on hospitalizations, physician office visits, and mortality, CVD is defined according to *ICD* codes given in Chapter 27 of the present document. This definition includes all diseases of the circulatory system, as well as congenital CVD. Unless so specified, an estimate for total CVD does not include congenital CVD. Prevalence of CVD includes people with hypertension, HD, stroke, PAD, and diseases of the veins.

Race

Data published by governmental agencies for some racial groups are considered unreliable because of the small sample

size in the studies. Because we try to provide data for as many racial groups as possible, we show these data for informational and comparative purposes.

Contacts

If you have questions about statistics or any points made in this Update, please contact the AHA National Center, Office of Science & Medicine at statistics@heart.org. Direct all media inquiries to News Media Relations at inquiries@heart.org or 214-706-1173.

We do our utmost to ensure that this Update is error free. If we discover errors after publication, we will provide corrections at http://www.heart.org/statistics and in the journal *Circulation*.

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2. Cardiovascular Health

See Tables 2-1 through 2-6 and Charts 2-1 through 2-16.

In 2011, the AHA created a new set of central Strategic Impact Goals to drive organizational priorities for the current decade:

> *By 2020, to improve the cardiovascular health of all Americans by 20%, while reducing deaths from CVDs and stroke by 20%.*[1]

These goals introduce a new concept of *cardiovascular health*, characterized by 7 metrics ("Life's Simple 7"[2]), including health behaviors (diet quality, PA, smoking, BMI) and health factors (blood cholesterol, BP, blood glucose). *Ideal cardiovascular health* is defined by the absence of clinically manifest CVD together with the simultaneous presence of optimal levels of all 7 metrics, including not smoking and having a healthy diet pattern, sufficient PA, normal body weight, and normal levels of TC, BP, and fasting blood glucose in the absence of drug treatment (Table 2-1). Because a spectrum of cardiovascular health is possible and the ideal cardiovascular health profile is known to be rare in the US population, a broader spectrum of cardiovascular health can also be represented as being "ideal," "intermediate," or "poor" for each of the health behaviors and health factors.[1] Table 2-1 provides the specific definitions for ideal, intermediate, and poor cardiovascular health for each of the 7 metrics, both for adults and for children.

This concept of cardiovascular health represents a new focus for the AHA, with 3 central and novel emphases:

- An expanded focus on CVD prevention and promotion of positive "cardiovascular health," in addition to the treatment of established CVD
- Efforts to promote both healthy behaviors (healthy diet pattern, appropriate energy intake, PA, and nonsmoking) and healthy biomarker levels (optimal blood lipids, BP, glucose levels) throughout the lifespan
- Population-level health promotion strategies to shift the majority of the public toward greater cardiovascular health, in addition to targeting those individuals at greatest CVD risk, because healthy lifestyles in all domains are uncommon throughout the US population

Beginning in 2011, and recognizing the time lag in the nationally representative US data sets, this chapter in the annual Statistical Update evaluates and publishes metrics and information to provide insights into both progress toward meeting the 2020 AHA goals and areas that require greater attention to meet these goals. The AHA has advocated for raising the visibility of patient-reported cardiovascular health status, which includes symptom burden, functional status, and health-related quality of life, as an indicator of cardiovascular health in future organizational goal setting.[3]

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Abbreviations Used in Chapter 2

AHA	American Heart Association
BMI	body mass index
BP	blood pressure
BRFSS	Behavioral Risk Factor Surveillance System
CHD	coronary heart disease
CI	confidence interval
CV	cardiovascular
CVD	cardiovascular disease
DASH	Dietary Approaches to Stop Hypertension
DBP	diastolic blood pressure
DM	diabetes mellitus
FPG	fasting plasma glucose
HbA_{1c}	hemoglobin A_{1c} (glycosylated hemoglobin)
HBP	high blood pressure
HD	heart disease
HF	heart failure
HR	hazard ratio
ICD-10	*International Classification of Diseases, 10th Revision*
IMT	intima-media thickness
NH	Non-Hispanic
NHANES	National Health and Nutrition Examination Survey
PA	physical activity
PE	physical education
REGARDS	Reasons for Geographic and Racial Differences in Stroke
SBP	systolic blood pressure
SSB	sugar-sweetened beverage
TC	total cholesterol

Relevance of Ideal Cardiovascular Health

- Since the AHA announced its 2020 Impact Goals, multiple independent investigations have confirmed the importance of these metrics and the concept of cardiovascular health. Findings include strong inverse, stepwise associations in the United States of the metrics and cardiovascular health with all-cause mortality, CVD mortality, and HF; with preclinical measures of atherosclerosis such as carotid IMT, arterial stiffness, and coronary artery calcium prevalence and progression; with physical functional impairment; and with cognitive decline and depression.[4] Similar relationships have also been seen in non-US populations.[4–6]
- In many of these analyses, ideal health behaviors and ideal health factors are each independently associated with lower CVD risk in a stepwise fashion (Chart 2-1). In other words, across any level of health behaviors, health factors are still associated with incident CVD, whereas across any level of health factors, health behaviors are still associated with incident CVD.[7]
- In addition, only modest intercorrelations are apparent between different cardiovascular health metrics. On the basis of NHANES 1999 to 2002, these ranged from a correlation of −0.12 between PA and HbA_{1c} to a correlation of 0.29 between BMI and HbA_{1c}. Thus, substantial independent variation in each metric exists, and each is independently related to cardiovascular outcomes.[8]
- These findings corroborate the independent value of targeting each of these 7 metrics as separate aims.

- Analyses from the US Burden of Disease Collaborators demonstrated that each of the 7 health factors and behaviors caused substantial mortality and morbidity in the United States in 2010. The top risk factor related to overall disease burden was suboptimal diet, followed by tobacco smoking, high BMI, raised BP, high fasting plasma glucose, and physical inactivity.[9]
- A stepwise association was present between the number of ideal cardiovascular health metrics and risk of death based on NHANES 1988 to 2006 data.[10] The HRs for people with 6 or 7 ideal health metrics compared with 0 ideal health metrics were 0.49 (95% CI, 0.33–0.74) for all-cause mortality, 0.24 (95% CI, 0.13–0.47) for CVD mortality, and 0.30 (95% CI, 0.13–0.68) for ischemic HD mortality.[10] Ford et al[8] demonstrated similar relationships.
- The adjusted population attributable fractions for CVD mortality were as follows[10]:

  —40.6% (95% CI, 24.5%–54.6%) for HBP
  —13.7% (95% CI, 4.8%–22.3%) for smoking
  —13.2% (95% CI, 3.5%–29.2%) for poor diet
  —11.9% (95% CI, 1.3%–22.3%) for insufficient PA
  —8.8% (95% CI, 2.1%–15.4%) for abnormal glucose levels

- The adjusted population attributable fractions for ischemic HD mortality were as follows[10]:

  —34.7% (95% CI, 6.6%–57.7%) for HBP
  —16.7% (95% CI, 6.4%–26.6%) for smoking
  —20.6% (95% CI, 1.2%–38.6%) for poor diet
  —7.8% (95% CI, 0%–22.2%) for insufficient PA
  —7.5% (95% CI, 3.0%–14.7%) for abnormal glucose levels

- The REGARDS cohort also demonstrated a stepwise association between cardiovascular health metrics and incident stroke. Using a cardiovascular health score scale ranging from 0 to 14, every unit increase in cardiovascular health was associated with an 8% lower risk of incident stroke (HR, 0.92; 95% CI, 0.88–0.95), with a similar effect size for white (HR, 0.91; 95% CI, 0.86–0.96) and black (HR, 0.93; 95% CI, 0.87–0.98) participants.[11]
- The Cardiovascular Lifetime Risk Pooling Project showed that adults with all-optimal risk factor levels (similar to having ideal cardiovascular health factor levels of cholesterol, blood sugar, and BP, as well as nonsmoking) have substantially longer overall and CVD-free survival than those who have poor levels of ≥1 of these cardiovascular health factor metrics. For example, at an index age of 45 years, men with optimal risk factor profiles lived on average 14 years longer free of all CVD events, and 12 years longer overall, than individuals with ≥2 risk factors.[12]
- Better cardiovascular health is associated with less incident HF[13]; less subclinical vascular disease[14,15]; better global cognitive performance and cognitive function[16,17]; lower prevalence[18] and incidence[19] of depressive symptoms; and lower loss of physical functional status.[20]
- The AHA's 2020 Strategic Impact Goals are to improve cardiovascular health among all Americans. On the basis of NHANES 1999 to 2006, several social risk factors (low family income, low education level, minority race, and single-living status) were related to a lower likelihood of attaining better cardiovascular health as measured by Life's Simple 7 scores.[21]

Cardiovascular Health: Current Prevalence

(See Charts 2-2 through 2-9.)

- The most up-to-date data on national prevalence of ideal, intermediate, and poor levels of each of the 7 cardiovascular health metrics are shown for adolescents and teens (Chart 2-2) and for adults (Chart 2-3).
- For most metrics, the prevalence of ideal levels of health behaviors and health factors is higher in US children than in US adults. The main exceptions are diet and PA, for which prevalences of ideal levels in children are similar to (for PA) or worse than (for diet) those in adults.
- Among children (Chart 2-2), the prevalence (unadjusted) of ideal levels of cardiovascular health behaviors and factors currently varies from <1% for the healthy diet pattern (ie, <1 in 100 US children meets at least 4 of the 5 dietary components) to >80% for the smoking, BP, and fasting glucose metrics.
- Among US adults (Chart 2-3), the age-standardized prevalence of ideal levels of cardiovascular health behaviors and factors currently varies from about 1.5% for having an ideal AHA diet score of 78% for never having smoked or being a former smoker who has quit for >12 months.
- Age-standardized and age-specific prevalence estimates for ideal cardiovascular health and for ideal levels of each of its components are shown for 2011 to 2012 in Table 2-2. The prevalence of ideal levels across 7 health factors and health behaviors generally declined with age, with much lower prevalence among older versus younger age groups. The exception was diet, for which prevalence of ideal levels was highest in older adults.
- Chart 2-4 displays the prevalence estimates for the population of US children (12–19 years of age) meeting different numbers of criteria for ideal cardiovascular health (out of 7 possible) in 2009 to 2010.

  —Few US children (≈5%) meet only 0, 1, or 2 criteria for ideal cardiovascular health.
  —Nearly half of US children (49%) meet 3 or 4 criteria for ideal cardiovascular health, and ≈45% meet 5 or 6 criteria (mostly 5 criteria).
  —Virtually no children meet all 7 criteria for ideal cardiovascular health.

- Charts 2-5 and 2-6 display the age-standardized prevalence estimates of US adults meeting different numbers of criteria for ideal cardiovascular health (out of 7 possible) in 2011 to 2012, overall and stratified by age, sex, and race.

  —Approximately 1% of US adults have 0 of the 7 criteria at ideal levels, and another 16% meet only 1 of 7 criteria. This is much worse than among children.
  —Most US adults (≈63%) have 2, 3, or 4 criteria at ideal cardiovascular health, with ≈1 in 5 adults within each of these categories.
  —Approximately 13% of US adults meet 5 criteria, 5% meet 6 criteria, and virtually 0% meet 7 criteria at ideal levels.
  —Presence of ideal cardiovascular health is both age and sex related (Chart 2-5). Younger adults are more likely to meet greater numbers of ideal metrics than are older adults. More than 60% of Americans >60 years of age have ≤2 metrics at ideal levels. At any age, women tend to have more metrics at ideal levels than do men.

—Race is also related to presence of ideal cardiovascular health (Chart 2-6). Blacks and Hispanics tend to have fewer metrics at ideal levels than whites or other races. Approximately 6 in 10 white adults and 7 in 10 black or Hispanic adults have no more than 3 of 7 metrics at ideal levels.

- Chart 2-7 displays the age-standardized percentages of US adults and percentages of children who have ≥5 of the metrics (out of 7 possible) at ideal levels.

—Approximately 46% of US children 12 to 19 years of age have ≥5 metrics at ideal levels, with slightly lower prevalence in boys (44%) than in girls (47%).
—By comparison, only 18% of US adults have ≥5 metrics with ideal levels, with lower prevalence in men (12%) than in women (24%).
—All populations have improved since baseline year 2007 to 2008.

- Chart 2-8 displays the age-standardized percentages of US adults and percentages of children by race/ethnicity who have ≥5 of the metrics (out of 7 possible) at ideal levels.

—Among both children and adults, non-Hispanic whites tend to have a higher prevalence of having ≥5 metrics at ideal levels.
—Among children, more non-Hispanic blacks have ≥5 metrics with ideal levels; however, among adults, Hispanics have a higher prevalence than non-Hispanic blacks.
—Approximately 5 in 10 non-Hispanic white children, 4 in 10 non-Hispanic black children, and 3 in 10 Hispanic children have ≥5 metrics at ideal levels.
—By comparison, among adults, only ≈2 in 10 of non-Hispanic whites and Hispanics and 1 in 10 of non-Hispanic blacks have ≥5 metrics at ideal levels.

- Chart 2-9 displays the age-standardized percentages of US adults meeting different numbers of criteria for both poor and ideal cardiovascular health. Meeting the AHA 2020 Strategic Impact Goals is predicated on reducing the relative percentage of those with poor levels while increasing the relative percentage of those with ideal levels for each of the 7 metrics.

—Approximately 81% of US adults have ≥1 metric at poor levels.
—Approximately 28% of US adults have ≥3 metrics at poor levels.
—Few US adults (1.6%) have ≥5 metrics at poor levels.
—More US adults have 4 to 6 ideal metrics than 4 to 6 poor metrics.

- Using data from the BRFSS, Fang and colleagues[22] estimated the prevalence of ideal cardiovascular health by state, which ranged from 1.2% (Oklahoma) to 6.9% (District of Columbia). Southern states tended to have higher rates of poor cardiovascular health, lower rates of ideal cardiovascular health, and lower mean cardiovascular health scores than New England and Western states (Chart 2-10).

Cardiovascular Health: Trends Over Time

- The trends over the past decade in each of the 7 cardiovascular health metrics (for diet, trends from 2003–2004 to 2011–2011) are shown in Chart 2-11 (for children 12–19 years of age) and Chart 2-12 (for adults ≥20 years of age).

—The prevalence of both children and adults meeting the dietary goals improved between 2003 to 2004 and 2011 to 2012. The prevalence of ideal levels of diet increased from 0.2% to 0.6% in children and from 0.7% to 1.5% in adults (Charts 5-2 and 5-3, Nutrition chapter). The prevalence of intermediate levels of diet increased from 30.6% to 44.7% in children and from 49.0% to 57.5% in adults. These improvements were largely attributable to increased whole grain consumption and decreased sugar-sweetened beverage consumption in both children and adults, as well as small, nonsignificant trends in increased consumption of fruits and vegetables (Charts 5-4 and 5-5, Nutrition chapter). No major trends were evident in either children or adults meeting the target for consumption of fish or sodium.
—Fewer children over time are meeting the ideal BMI metric, whereas more are meeting the ideal smoking and TC metrics. Other metrics do not show consistent trends over time in children.
—More adults over time are meeting the smoking metric, whereas fewer are meeting the BMI and glucose metrics. Trends for other metrics are not evident over time in adults.

- On the basis of NHANES data from 1988 to 2008, if current trends continue, estimated cardiovascular health is projected to improve by 6% between 2010 and 2020, short of the AHA's goal of 20% improvement (Chart 2-13).[23] On the basis of current trends among individual metrics, anticipated declines in the prevalence of smoking, high cholesterol, and HBP (in men) would be offset by substantial increases in the prevalence of obesity and DM and smaller changes in ideal dietary patterns or PA.[23]
- On the basis of these projections in cardiovascular health factors and behaviors, CHD deaths are projected to decrease by 30% between 2010 and 2020 because of projected improvements in TC, SBP, smoking, and PA (≈167 000 fewer deaths), offset by increases in DM and BMI (≈24 000 more deaths).[24]

CVD Mortality

(See Charts 2-14 through 2-16.)

- In 2013, the age-standardized death rate attributable to all CVD in the US population was 223.9 per 100 000, down 13.7% from 259.4 per 100 000 in 2007 (baseline data for the 2020 Impact Goals on CVD and stroke mortality).[25]
- The age-standardized death rate in 2013 attributable to stroke was 36.2 per 100 000, a decrease of 16.8% from 2007. Death rates attributable to CHD and other CVDs were 102.6 and 84.1 per 100 000 in 2013, reductions of 20.6% and 1.5%, respectively.[25]

- Between 2007 and 2013, the CVD and stroke death rates decreased 12.5% and 16.1%, respectively, in non-Hispanic whites; 16.5% and 20.2% in non-Hispanic blacks; 18.1% and 17.3% in Hispanics; 15.0% and 19.6% in non-Hispanic Asian and Pacific Islanders; and 11.3% and 22.5% in non-Hispanic American Indian or Alaska Natives.[25]

Achieving the 2020 Impact Goals

- To achieve the AHA's 2020 Impact Goals of reducing deaths attributable to CVD and stroke by 20%, continued emphasis is needed on the treatment of acute CVD events and secondary prevention through treatment and control of health behaviors and risk factors.
- Taken together, these data continue to demonstrate both the tremendous relevance of the AHA 2020 Impact Goals for cardiovascular health and the progress that will be needed to achieve these goals over the next decade.
- For each cardiovascular health metric, modest shifts in the population distribution toward improved health would produce appreciable increases in the proportion of Americans in both ideal and intermediate categories. For example, on the basis of NHANES 2011 to 2012, the current prevalence of ideal levels of BP among US adults is 42.2%. To achieve the 2020 goals, a 20% relative improvement would require an increase in this proportion to 50.6% by 2020 (42.2% × 1.20). On the basis of NHANES data, a reduction in population mean BP of just 2 mm Hg would result in 53.6% of US adults having ideal levels of BP, which represents a 27.2% relative improvement in this metric (Table 2-3). Larger population reductions in BP would lead to even greater numbers of people with ideal levels. Such small reductions in population BP could result from small health behavior changes at a population level, such as increased PA, increased fruit and vegetable consumption, decreased sodium intake, decreased adiposity, or some combination of these and other lifestyle changes, with resulting substantial projected decreases in CVD rates among US adults.[26]
- A range of complementary strategies and approaches can lead to improvements in cardiovascular health. These include each of the following:
  - —Individual-focused approaches, which target lifestyle and treatments at the individual level (Table 2-4)
  - —Healthcare systems approaches, which encourage, facilitate, and reward efforts by providers to improve health behaviors and health factors (Table 2-5)
  - —Population approaches, which target lifestyle and treatments in schools or workplaces, local communities, and states, as well as throughout the nation (Table 2-6)
- Such approaches can focus on both (1) improving cardiovascular health among those who currently have less than optimal levels and (2) preserving cardiovascular health among those who currently have ideal levels (in particular, children, adolescents, and young adults) as they age.
- The metrics with the greatest potential for improvement in the United States are health behaviors, including diet quality, PA, and body weight. However, each of the 7 cardiovascular health metrics can be improved and deserves major focus.

Table 2-1. Definitions of Poor, Intermediate, and Ideal Cardiovascular Health for Each Metric in the AHA 2020 Goals

	Level of Cardiovascular Health for Each Metric		
	Poor	Intermediate	Ideal
Current smoking			
Adults ≥20 y of age	Yes	Former ≥12 mo	Never or quit >12 mo
Children 12–19 y of age*	Tried during the prior 30 d	…	Never tried; never smoked whole cigarette
BMI†			
Adults ≥20 y of age	≥30 kg/m^2	25–29.9 kg/m^2	<25 kg/m^2
Children 2–19 y of age	>95th percentile	85th–95th percentile	<85th percentile
PA			
Adults ≥20 y of age	None	1–149 min/wk moderate or 1–74 min/wk vigorous or 1–149 min/wk moderate + 2×vigorous	≥150 min/wk moderate or ≥75 min/wk vigorous or ≥150 min/wk moderate + 2×vigorous
Children 12–19 y of age	None	>0 and <60 min of moderate or vigorous every day	≥60 min of moderate or vigorous every day
Healthy diet pattern, No. of components (AHA diet score)‡			
Adults ≥20 y of age	<2	2–3	4–5
Children 5–19 y of age	<2	2–3	4–5
Total cholesterol, mg/dL			
Adults ≥20 y of age	≥240	200–239 or treated to goal	<200
Children 6–19 y of age	≥200	170–199	<170
Blood pressure			
Adults ≥20 y of age	SBP ≥140 mm Hg or DBP ≥90 mm Hg	SBP 120–139 mm Hg or DBP 80–89 mm Hg or treated to goal	<120 mm Hg/<80 mm Hg
Children 8–19 y of age	>95th percentile	90th–95th percentile or SBP ≥120 mm Hg or DBP ≥80 mm Hg	<90th percentile
Fasting plasma glucose, mg/dL			
Adults ≥20 y of age	≥126	100–125 or treated to goal	<100
Children 12–19 y of age	≥126	100–125	<100

AHA indicates American Heart Association; BMI, body mass index; DBP, diastolic blood pressure; ellipses (. . .), data not available; PA, physical activity; and SBP, systolic blood pressure.

*Age ranges in children for each metric depend on guidelines and data availability.

†Represents appropriate energy balance, that is, appropriate dietary quantity and PA to maintain normal body weight.

‡In the context of a healthy dietary pattern that is consistent with a Dietary Approaches to Stop Hypertension [DASH]–type eating pattern, to consume ≥4.5 cups/d of fruits and vegetables, ≥2 servings/wk of fish, and ≥3 servings/d of whole grains and no more than 36 oz/wk of sugar-sweetened beverages and 1500 mg/d of sodium. The consistency of one's diet with these dietary targets can be described using an alternative continuous AHA diet score, scaled from 0 to 100 (see chapter on Nutrition).

Table 2-2. Prevalence of Ideal Cardiovascular Health and Its Components in the US Population in Selected Age Strata: NHANES 2011 to 2012

	Age 12–19 y	Age ≥20 y*	Age 20–39 y	Age 40–59 y	Age ≥60 y
Ideal CV health profile (7/7)	0.0 (0.0)	0.0 (0.0)	0.1 (0.1)	0.0 (0.0)	0.0 (0.0)
≥6 Ideal	11.2 (2.5)	4.6 (0.8)	8.7 (1.7)	2.6 (0.8)	1.3 (0.9)
≥5 Ideal	45.5 (3.8)	18.0 (1.5)	32.7 (3.0)	10.1 (1.6)	5.3 (1.7)
Ideal health factors (4/4)	47.3 (2.1)	15.9 (1.2)	30.6 (2.4)	8.1 (1.2)	2.6 (1.2)
Total cholesterol <200 mg/dL	75.7 (1.9)	46.6 (0.7)	70.4 (1.7)	34.2 (1.7)	23.9 (1.1)
SBP <120/DBP <80 mm Hg	82.3 (1.6)	42.2 (1.3)	64.4 (2.1)	34.4 (1.5)	15.7 (1.6)
Not current smoker	87.1 (1.1)	77.8 (1.3)	75.2 (2.1)	74.3 (1.7)	87.1 (1.3)
FPG <100 mg/dL	81.6 (2.5)	53.0 (1.5)	70.0 (2.3)	49.6 (2.4)	28.6 (2.0)
Ideal health behaviors (4/4)	0.1 (0.1)	0.5 (0.2)	0.3 (0.2)	0.4 (0.3)	0.6 (0.2)
PA at goal	36.5 (2.6)	44.0 (1.8)	53.0 (2.2)	41.0 (2.4)	35.2 (2.3)
Not current smoker	87.1 (1.1)	77.8 (1.3)	75.2 (2.1)	74.3 (1.7)	87.1 (1.3)
BMI <25 kg/m^2	64.7 (2.1)	31.3 (1.4)	39.7 (2.8)	24.7 (1.4)	28.4 (2.1)
4–5 Diet goals met†	0.5 (0.4)	1.6 (0.4)	1.2 (0.5)	1.4 (0.4)	2.2 (0.4)
Fruits and vegetables ≥4.5 cups/d	6.8 (1.7)	17.2 (1.3)	12.7 (1.2)	19.3 (2.0)	22.8 (2.3)
Fish ≥2 servings/wk	11.0 (1.6)	21.2 (1.6)	19.0 (1.6)	21.2 (2.4)	25.4 (2.1)
Sodium <1500 mg/d	1.0 (0.3)	3.1 (0.4)	2.5 (0.5)	4.1 (0.8)	2.4 (0.6)
SSB <36 oz/wk	45.9 (1.9)	66.0 (2.0)	56.8 (3.0)	66.4 (3.3)	82.2 (1.4)
Whole grains ≥3 1 oz/d	7.5 (1.9)	12.0 (0.8)	10.2 (1.2)	10.9 (1.3)	16.3 (1.4)
Secondary diet metrics					
Nuts/legumes/seeds ≥4 servings/wk	29.2 (2.6)	42.0 (1.0)	40.0 (2.2)	43.5 (1.1)	43.8 (2.5)
Processed meats <2 servings/wk	60.6 (3.5)	62.1 (1.2)	61.8 (1.4)	61.1 (2.1)	64.2 (2.4)
Saturated fat <7% total kcal	18.2 (2.3)	25.9 (1.3)	26.1 (2.0)	24.8 (2.0)	28.6 (2.5)

BMI indicates body mass index; CV, cardiovascular; DBP, diastolic blood pressure; FPG, fasting plasma glucose; NHANES, National Health and Nutrition Examination Survey; PA, physical activity; SBP, systolic blood pressure; and SSB, sugar-sweetened beverages.

Data are mean (standard error).

*Standardized to the age distribution of the 2000 US standard population.

†Scaled to 2000 kcal/d and in the context of appropriate energy balance and a DASH (Dietary Approaches to Stop Hypertension)–type eating pattern.

Table 2-3. Reduction in BP Required to Increase Prevalence of Ideal BP Among Adults ≥20 Years of Age: NHANES 2011 to 2012

Percent BP ideal among adults, 2011–2012	42.17
20% Relative increase in ideal BP among adults	50.60
Percent whose BP would be ideal if population mean BP were lowered by the following*:	
2 mm Hg	53.62
3 mm Hg	57.42
4 mm Hg	59.39
5 mm Hg	63.40

Data are percentages and are standardized to the age distribution of the 2000 US standard population. BP indicates blood pressure; and NHANES, National Health and Nutrition Examination Survey.

*Reduction in BP = (observed average systolic–X mm Hg) and (observed average diastolic–X mm Hg).

Table 2-4. Evidence-Based Individual Approaches for Improving Health Behaviors and Health Factors in the Clinic Setting

- Set specific, shared, proximal goals (*Class I; Level of Evidence A*). Set specific, proximal goals with the patient, including a personalized plan to achieve the goals (eg, over the next 3 mo, increase fruits by 1 serving/d, reduce smoking by half a pack/d, or walk 30 min 3 times/wk).
- Establish self-monitoring (*Class I; Level of Evidence A*). Develop a strategy for self-monitoring, such as a dietary or physical activity diary or Web-based or mobile applications.
- Schedule regular follow-up (*Class I; Level of Evidence A*). Schedule regular follow-up (in-person, telephone, written, and/or electronic), with clear frequency and duration of contacts, to assess success, reinforce progress, and set new goals as necessary.
- Provide feedback (*Class I; Level of Evidence A*). Provide feedback on progress toward goals, including using in-person, telephone, and/or electronic feedback.
- Increase self-efficacy (*Class I; Level of Evidence A*). Increase the patient's perception that they can successfully change their behavior.*
- Use motivational interviewing† (*Class I; Level of Evidence A*). Use motivational interviewing when patients are resistant or ambivalent about behavior change.
- Provide long-term support (*Class I; Level of Evidence B*). Arrange long-term support from family, friends, or peers for behavior change, such as in other workplace, school, or community-based programs.
- Use a multicomponent approach (*Class I; Level of Evidence A*). Combine ≥2 of the above strategies into the behavior change efforts.

*Examples of approaches include mastery experiences (set a reasonable, proximal goal that the person can successfully achieve); vicarious experiences (have the person see someone with similar capabilities performing the behavior, such as walking on a treadmill or preparing a healthy meal); physiological feedback (explain to the patient when a change in their symptoms is related to worse or improved behaviors); and verbal persuasion (persuade the person that you believe in their capability to perform the behavior).

†Motivational interviewing represents use of individual counseling to explore and resolve ambivalence toward changing behavior. Major principles include fostering the person's own awareness and resolution of their ambivalence, as well as their own self-motivation to change, in a partnership with the counselor or provider.

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Table 2-5. Evidence-Based Healthcare Systems Approaches to Support and Facilitate Improvements in Health Behaviors and Health Factors[28–32]

- Electronic systems for scheduling and tracking initial visits and regular follow-up contacts for behavior change and treatments.
- Electronic medical records systems to help assess, track, and report on specific health behaviors (diet, PA, tobacco, body weight) and health factors (BP, cholesterol, glucose), as well as to provide feedback and the latest guidelines to providers.
- Practical paper or electronic toolkits for assessment of key health behaviors and health factors, including during, before, and after provider visits.
- Electronic systems to facilitate provision of feedback to patients on their progress during behavior change and other treatment efforts.
- Education and ongoing training for providers on evidence-based behavior change strategies, as well as the most relevant behavioral targets, including training on relevant ethnic and cultural issues.
- Integrated systems to provide coordinated care by multidisciplinary teams of providers, including physicians, nurse practitioners, dietitians, PA specialists, and social workers.
- Reimbursement guidelines and incentives that reward efforts to change health behaviors and health factors. Restructuring of practice goals and quality benchmarks to incorporate health behavior (diet, PA, tobacco, body weight) and health factor (BP, cholesterol, glucose) interventions and targets for both primary and secondary prevention.

BP indicates blood pressure; and PA, physical activity.

Table 2-6. Summary of Evidence-Based Population Approaches for Improving Diet, Increasing Physical Activity, and Reducing Tobacco Use*

Diet	
Media and education	Sustained, focused media and educational campaigns, using multiple modes, for increasing consumption of specific healthful foods or reducing consumption of specific less healthful foods or beverages, either alone (*Class IIa; Level of Evidence B*) or as part of multicomponent strategies (*Class I; Level of Evidence B*)†‡§
	On-site supermarket and grocery store educational programs to support the purchase of healthier foods (*Class IIa; Level of Evidence B*)†
Labeling and information	Mandated nutrition facts panels or front-of-pack labels/icons as a means to influence industry behavior and product formulations (*Class IIa; Level of Evidence B*)†
Economic incentives	Subsidy strategies to lower prices of more healthful foods and beverages (*Class I; Level of Evidence A*)†
	Tax strategies to increase prices of less healthful foods and beverages (*Class IIa; Level of Evidence B*)†
	Changes in both agricultural subsidies and other related policies to create an infrastructure that facilitates production, transportation, and marketing of healthier foods, sustained over several decades (*Class IIa; Level of Evidence B*)†
Schools	Multicomponent interventions focused on improving both diet and physical activity, including specialized educational curricula, trained teachers, supportive school policies, a formal PE program, healthy food and beverage options, and a parental/family component (*Class I; Level of Evidence A*)†
	School garden programs, including nutrition and gardening education and hands-on gardening experiences (*Class IIa; Level of Evidence A*)†
	Fresh fruit and vegetable programs that provide free fruits and vegetables to students during the school day (*Class IIa; Level of Evidence A*)†
Workplaces	Comprehensive worksite wellness programs with nutrition, physical activity, and tobacco cessation/prevention components (*Class IIa; Level of Evidence A*)†
	Increased availability of healthier food/beverage options and/or strong nutrition standards for foods and beverages served, in combination with vending machine prompts, labels, or icons to make healthier choices (*Class IIa; Level of Evidence B*)†
Local environment	Increased availability of supermarkets near homes (*Class IIa; Level of Evidence B*)†‡‖
Restrictions and mandates	Restrictions on television advertisements for less healthful foods or beverages advertised to children (*Class I; Level of Evidence B*)†
	Restrictions on advertising and marketing of less healthful foods or beverages near schools and public places frequented by youths (*Class IIa; Level of Evidence B*)†
	General nutrition standards for foods and beverages marketed and advertised to children in any fashion, including on-package promotion (*Class IIa; Level of Evidence B*)†
	Regulatory policies to reduce specific nutrients in foods (eg, *trans* fats, salt, certain fats) (*Class I; Level of Evidence B*)†§
Physical activity	
Labeling and information	Point-of-decision prompts to encourage use of stairs (*Class IIa; Level of Evidence A*)†
Economic incentives	Increased gasoline taxes to increase active transport/commuting (*Class IIa; Level of Evidence B*)†
Schools	Multicomponent interventions focused on improving both diet and physical activity, including specialized educational curricula, trained teachers, supportive school policies, a formal PE program, serving of healthy food and beverage options, and a parental/family component (*Class IIa; Level of Evidence A*)†
	Increased availability and types of school playground spaces and equipment (*Class I; Level of Evidence B*)†
	Increased number of PE classes, revised PE curricula to increase time in at least moderate activity, and trained PE teachers at schools (*Class IIa; Level of Evidence A/Class IIb; Level of Evidence A*¶)†
	Regular classroom physical activity breaks during academic lessons (*Class IIa; Level of Evidence A*)†§
Workplaces	Comprehensive worksite wellness programs with nutrition, physical activity, and tobacco cessation/prevention components (*Class IIa; Level of Evidence A*)†
	Structured worksite programs that encourage activity and also provide a set time for physical activity during work hours (*Class IIa; Level of Evidence B*)†
	Improving stairway access and appeal, potentially in combination with "skip-stop" elevators that skip some floors (*Class IIa; Level of Evidence B*)†
	Adding new or updating worksite fitness centers (*Class IIa; Level of Evidence B*)†
Local environment	Improved accessibility of recreation and exercise spaces and facilities (eg, building of parks and playgrounds, increasing operating hours, use of school facilities during nonschool hours) (*Class IIa; Level of Evidence B*)†
	Improved land-use design (eg, integration and interrelationships of residential, school, work, retail, and public spaces) (*Class IIa; Level of Evidence B*)†
	Improved sidewalk and street design to increase active commuting (walking or bicycling) to school by children (*Class IIa; Level of Evidence B*)†
	Improved traffic safety (*Class IIa; Level of Evidence B*)†
	Improved neighborhood aesthetics (to increase activity in adults) (*Class IIa; Level of Evidence B*)†
	Improved walkability, a composite indicator that incorporates aspects of land-use mix, street connectivity, pedestrian infrastructure, aesthetics, traffic safety, and/or crime safety (*Class IIa; Level of Evidence B*)†

(*Continued*)

Table 2-6. Continued

Smoking	
Media and education	Sustained, focused media and educational campaigns to reduce smoking, either alone *(Class IIa; Level of Evidence B)* or as part of larger multicomponent population-level strategies (*Class I; Level of Evidence A*)†
Labeling and information	Cigarette package warnings, especially those that are graphic and health related (*Class I; Level of Evidence B*)†‡§
Economic incentives	Higher taxes on tobacco products to reduce use and fund tobacco control programs (*Class I; Level of Evidence A*)†‡§
Schools and workplaces	Comprehensive worksite wellness programs with nutrition, physical activity, and tobacco cessation/prevention components (*Class IIa; Level of Evidence A*)†
Local environment	Reduced density of retail tobacco outlets around homes and schools (*Class I; Level of Evidence B*)†
	Development of community telephone lines for cessation counseling and support services (*Class I; Level of Evidence A*)†
Restrictions and mandates	Community (city, state, or federal) restrictions on smoking in public places (*Class I; Level of Evidence A*)†
	Local workplace-specific restrictions on smoking (*Class I; Level of Evidence A*)†‡§
	Stronger enforcement of local school-specific restrictions on smoking (*Class IIa; Level of Evidence B*)†
	Local residence-specific restrictions on smoking (*Class IIa; Level of Evidence B*)†§
	Partial or complete restrictions on advertising and promotion of tobacco products (*Class I; Level of Evidence B*)†

PE indicates physical education.
*The specific population interventions listed here are either a Class I or IIa recommendation with a Level of Evidence grade of either A or B.
†At least some evidence from studies conducted in high-income Western regions and countries (eg, North America, Europe, Australia, New Zealand).
‡At least some evidence from studies conducted in high-income non-Western regions and countries (eg, Japan, Hong Kong, South Korea, Singapore).
§At least some evidence from studies conducted in low- or middle-income regions and countries (eg, Africa, China, Pakistan, India).
||Based on cross-sectional studies only; only 2 longitudinal studies have been performed, with no significant relations seen.
¶*Class IIa; Level of Evidence A* for improving physical activity; *Class IIb; Level of Evidence B* for reducing adiposity.
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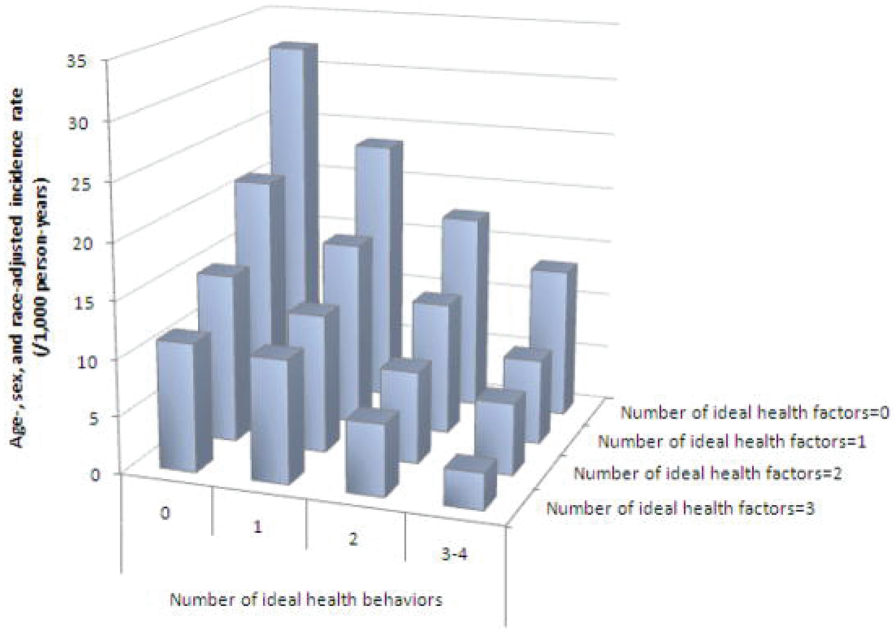

Chart 2-1. Incidence of cardiovascular disease according to the number of ideal health behaviors and health factors. Reprinted from Folsom et al[7] with permission from Elsevier. Copyright © 2011.

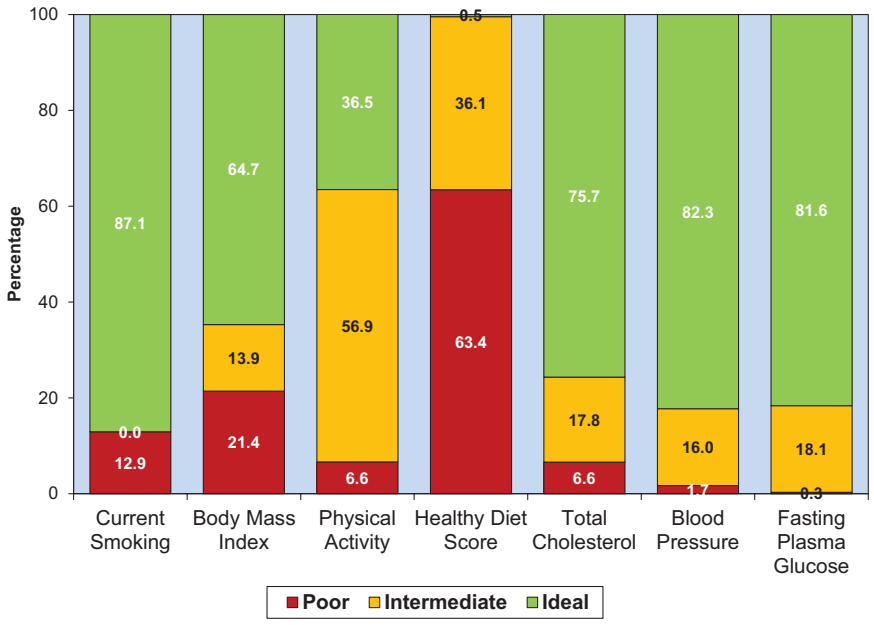

Chart 2-2. Prevalence (unadjusted) estimates for poor, intermediate, and ideal cardiovascular health for each of the 7 metrics of cardiovascular health in the American Heart Association 2020 goals among US children aged 12 to 19 years, National Health and Nutrition Examination Survey 2011 to 2012.

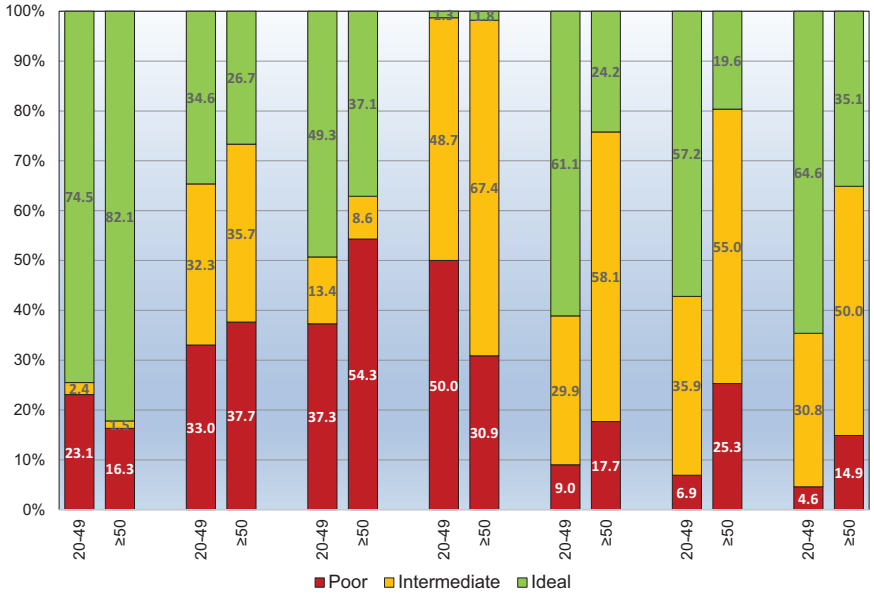

Chart 2-3. Prevalence (unadjusted) estimates of poor, intermediate, and ideal cardiovascular health for each of the 7 metrics of cardiovascular health in the American Heart Association 2020 goals among US adults aged 20 to 49 years and ≥50 years, National Health and Nutrition Examination Survey 2011 to 2012.

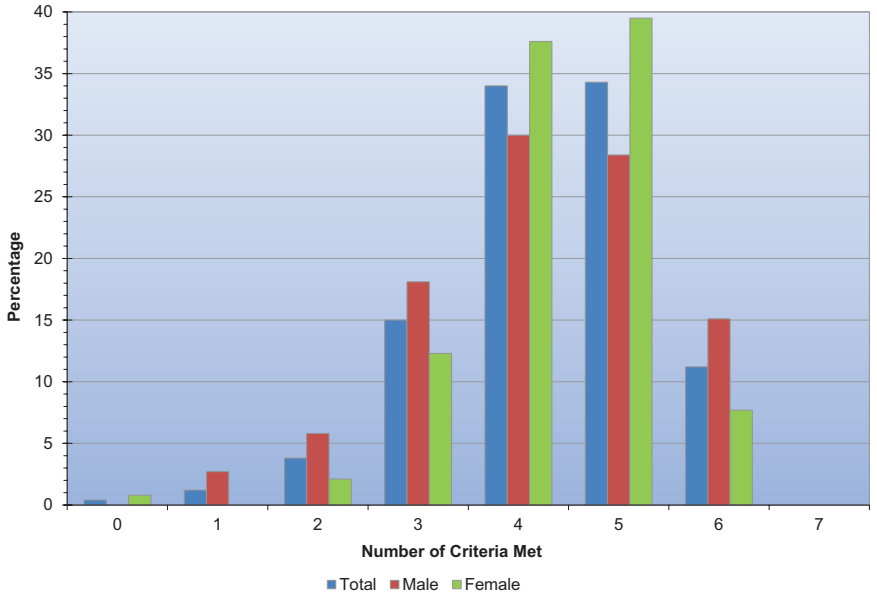

Chart 2-4. Proportion (unadjusted) of US children aged 12 to 19 years meeting different numbers of criteria for ideal cardiovascular health, overall and by sex, National Health and Nutrition Examination Survey 2011 to 2012.

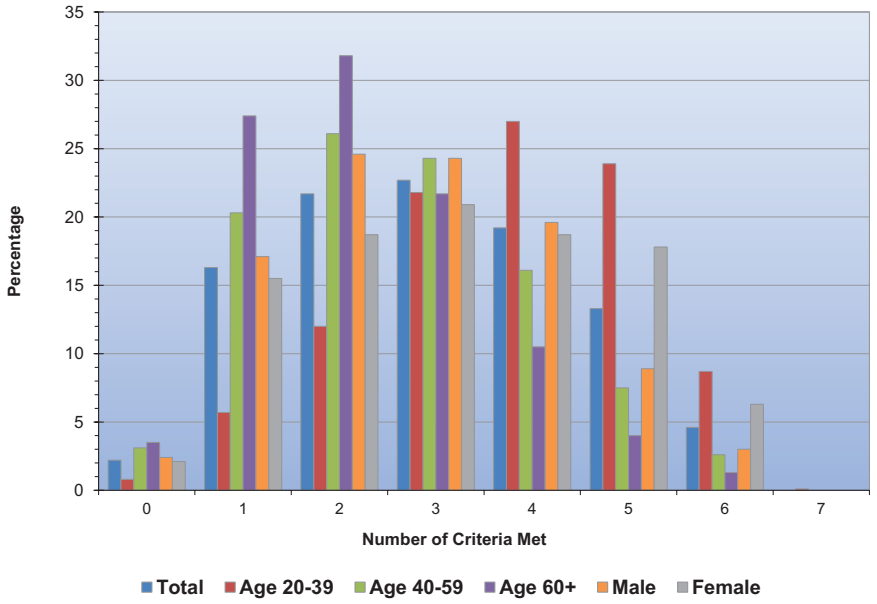

Chart 2-5. Age-standardized prevalence estimates of US adults aged ≥20 years meeting different numbers of criteria for ideal cardiovascular health, overall and by age and sex subgroups, National Health and Nutrition Examination Survey 2011 to 2012.

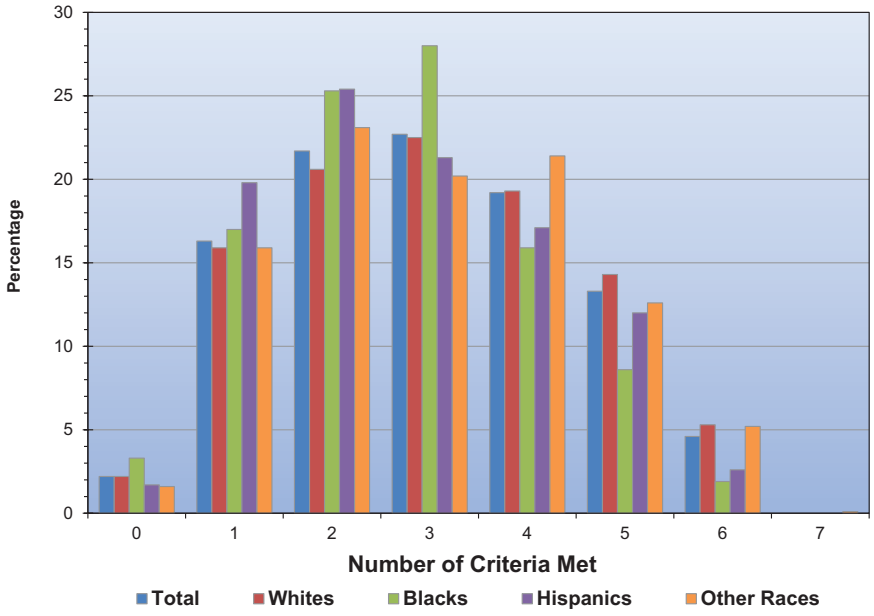

Chart 2-6. Age-standardized prevalence estimates of US adults aged ≥20 years meeting different numbers of criteria for ideal cardiovascular health, overall and in selected race subgroups, National Health and Nutrition Examination Survey 2011 to 2012.

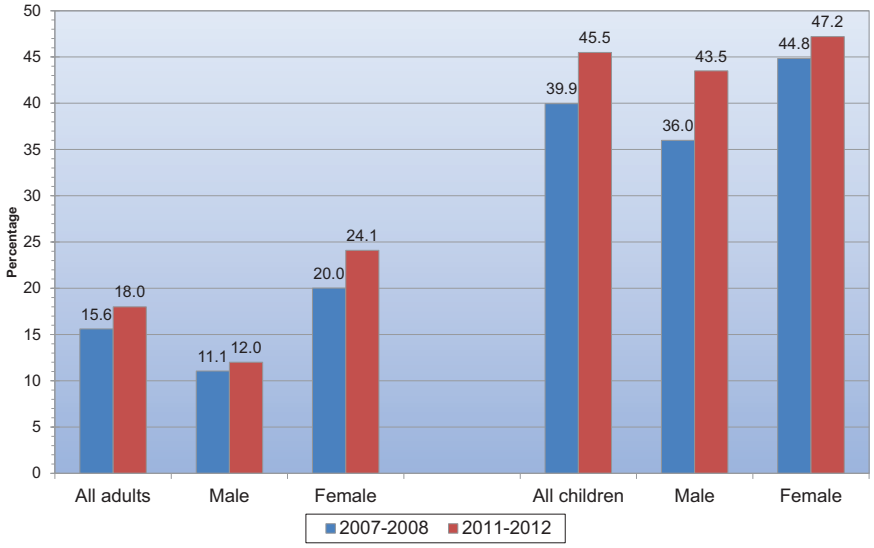

Chart 2-7. Prevalence of meeting ≥5 criteria for ideal cardiovascular health among US adults aged ≥20 years (age standardized) and US children aged 12 to 19 years, overall and by sex, National Health and Nutrition Examination Survey 2007 to 2008 and 2011 to 2012.

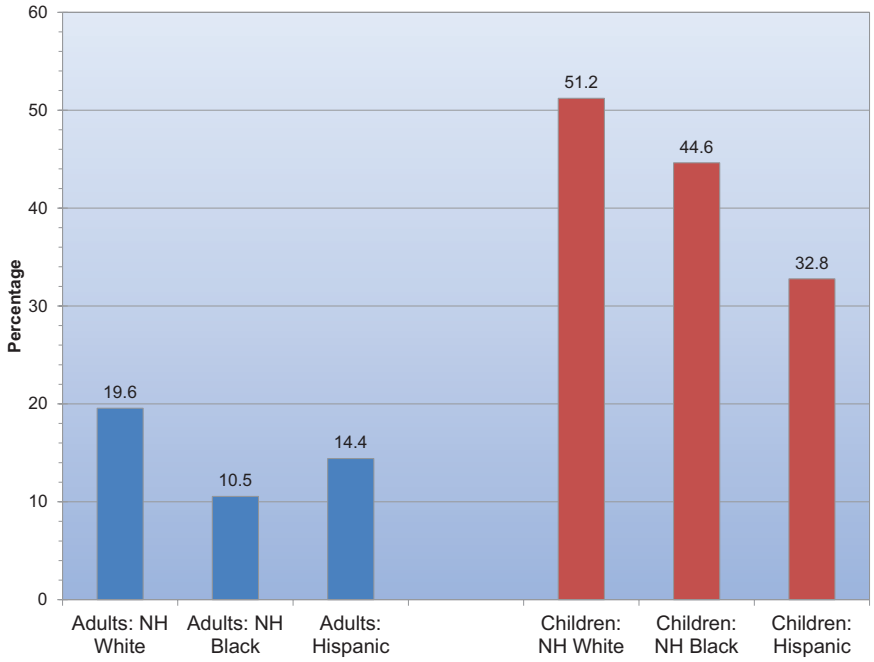

Chart 2-8. Prevalence of meeting ≥5 criteria for ideal cardiovascular health among US adults aged ≥20 years (age standardized) and US children aged 12 to 19 years, by race/ethnicity, National Health and Nutrition Examination Survey 2011 to 2012. NH indicates non-Hispanic.

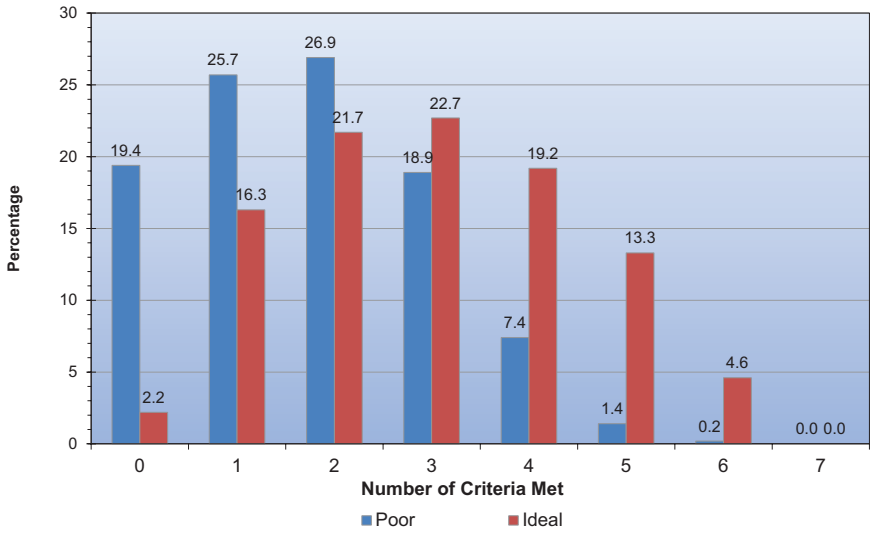

Chart 2-9. Age-standardized prevalence estimates of US adults meeting different numbers of criteria for ideal and poor cardiovascular health for each of the 7 metrics of cardiovascular health in the American Heart Association 2020 goals among US adults aged ≥20 years, National Health and Nutrition Examination Survey 2011 to 2012.

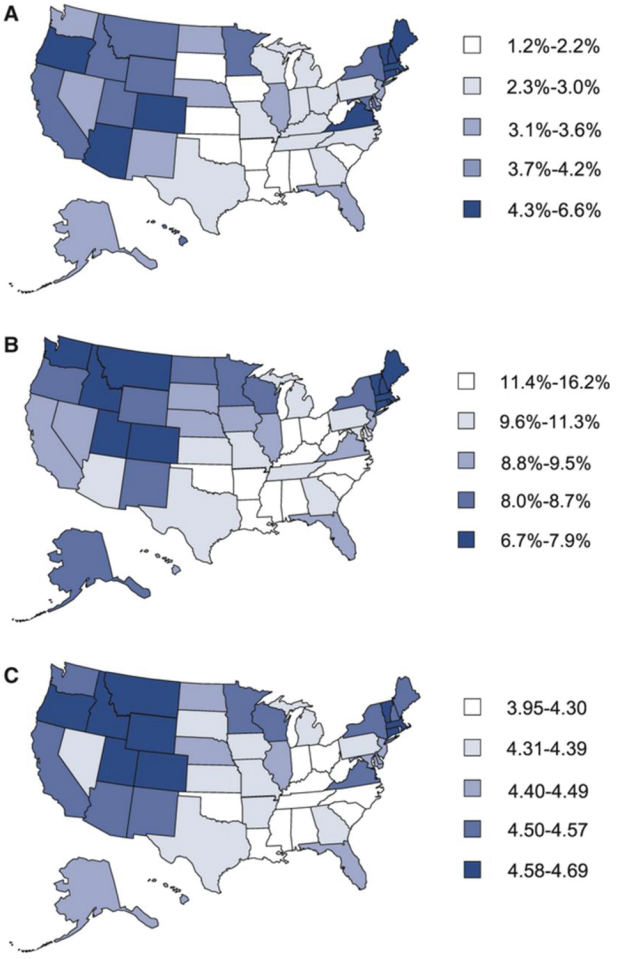

Chart 2-10. Age-standardized cardiovascular health status by US states, Behavioral Risk Factor Surveillance System, 2009. **A**, Age-standardized prevalence of population with ideal cardiovascular health by states. **B**, Age-standardized percentage of population with 0 to 2 cardiovascular health metrics by states. **C**, Age-standardized mean score of cardiovascular health metrics by states. Reprinted from Fang et al[22] with permission. Copyright © 2013, American Heart Association.

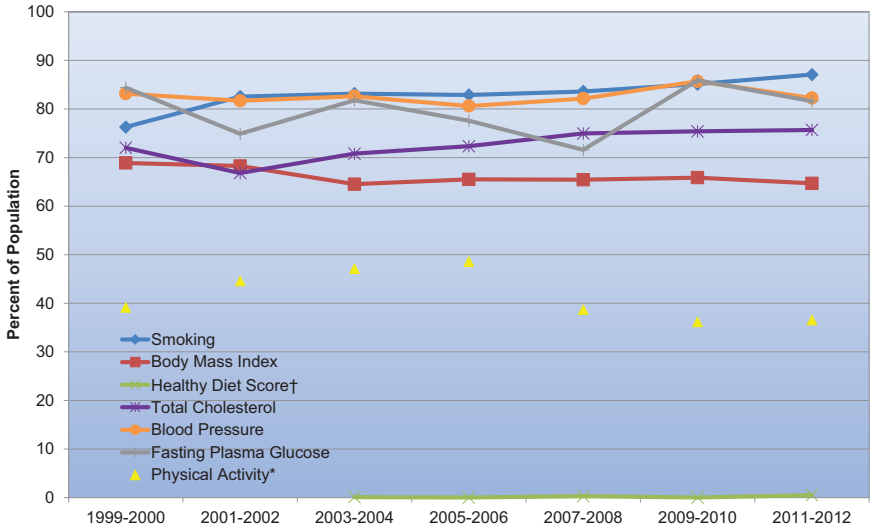

Chart 2-11. Trends in prevalence (unadjusted) of meeting criteria for ideal cardiovascular health for each of the 7 metrics of cardiovascular health in the American Heart Association 2020 goals among US children aged 12 to 19 years, National Health and Nutrition Examination Survey (NHANES) 1999 to 2000 through 2011 to 2012. *Because of changes in the physical activity questionnaire between different cycles of the NHANES survey, trends over time for this indicator should be interpreted with caution, and statistical comparisons should not be attempted. †Data for the Healthy Diet Score, based on a 2-day average intake, were only available for the 2003 to 2004, 2005 to 2006, 2007 to 2008, 2009 to 2010, and 2011 to 2012 NHANES cycles at the time of this analysis.

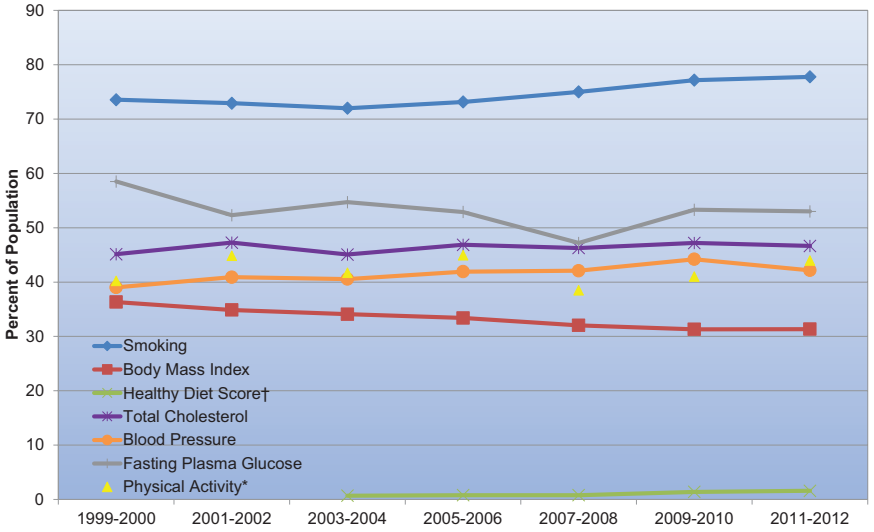

Chart 2-12. Age-standardized trends in prevalence of meeting criteria for ideal cardiovascular health for each of the 7 metrics of cardiovascular health in the American Heart Association 2020 goals among US adults aged ≥20 years, National Health and Nutrition Examination Survey (NHANES) 1999 to 2000 through 2011 to 2012. *Because of changes in the physical activity questionnaire between different cycles of the NHANES survey, trends over time for this indicator should be interpreted with caution, and statistical comparisons should not be attempted. †Data for the Healthy Diet Score, based on a 2-day average intake, were only available for the 2003 to 2004, 2005 to 2006, 2007 to 2008, 2009 to 2010 and 2011 to 2012 NHANES cycles at the time of this analysis.

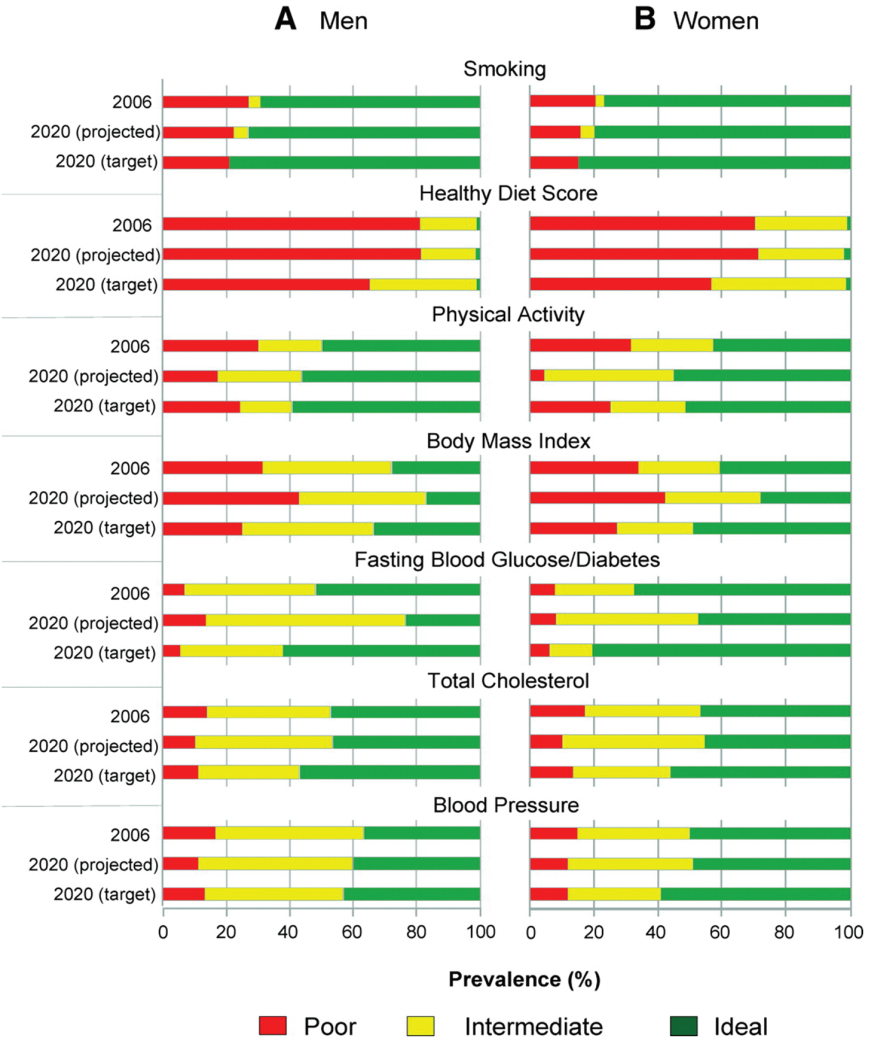

Chart 2-13. Prevalence of ideal, intermediate, and poor cardiovascular health metrics in 2006 (American Heart Association 2020 Impact Goals baseline year) and 2020 projections assuming current trends continue. The 2020 targets for each cardiovascular health metric assume a 20% relative increase in ideal cardiovascular health prevalence metrics and a 20% relative decrease in poor cardiovascular health prevalence metrics for men and women. Reprinted from Huffman et al[23] with permission. Copyright © 2012, American Heart Association.

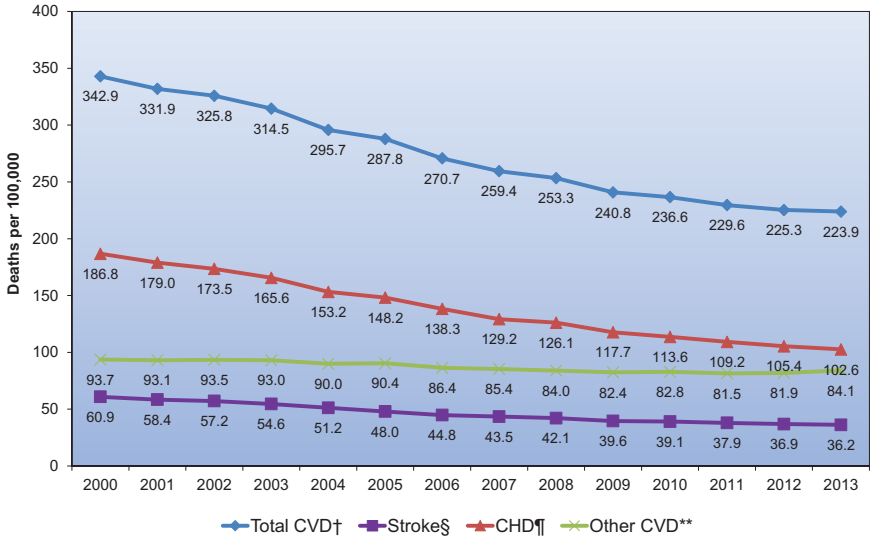

Chart 2-14. US age-standardized death rates* attributable to cardiovascular diseases, 2000 to 2013. CHD indicates coronary heart disease; and CVD, cardiovascular disease. *Directly standardized to the age distribution of the 2000 US standard population. †Total CVD: *International Classification of Diseases, 10th Revision* (*ICD-10*) I00 to I99, Q20 to Q28. §Stroke (all cerebrovascular disease): *ICD-10* I60 to I69. ¶CHD: *ICD-10* I20 to I25. **Other CVD: *ICD-10* I00 to I15, I26 to I51, I70 to I78, I80 to I89, I95 to I99. Source: Centers for Disease Control and Prevention, National Center for Health Statistics.[25]

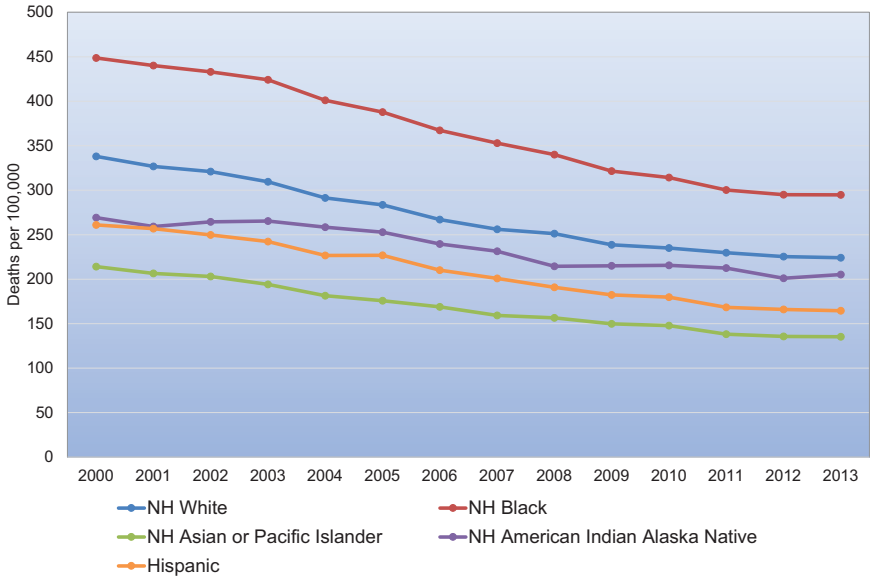

Chart 2-15. US age-standardized death rates* attributable to cardiovascular disease (CVD) by race/ethnicity, 2000 to 2013. NH indicates non-Hispanic.*Directly standardized to the age distribution of the 2000 US standard population. Total CVD: *International Classification of Diseases, 10th Revision* I00 to I99, Q20 to Q28. Source: Centers for Disease Control and Prevention, National Center for Health Statistics.[25]

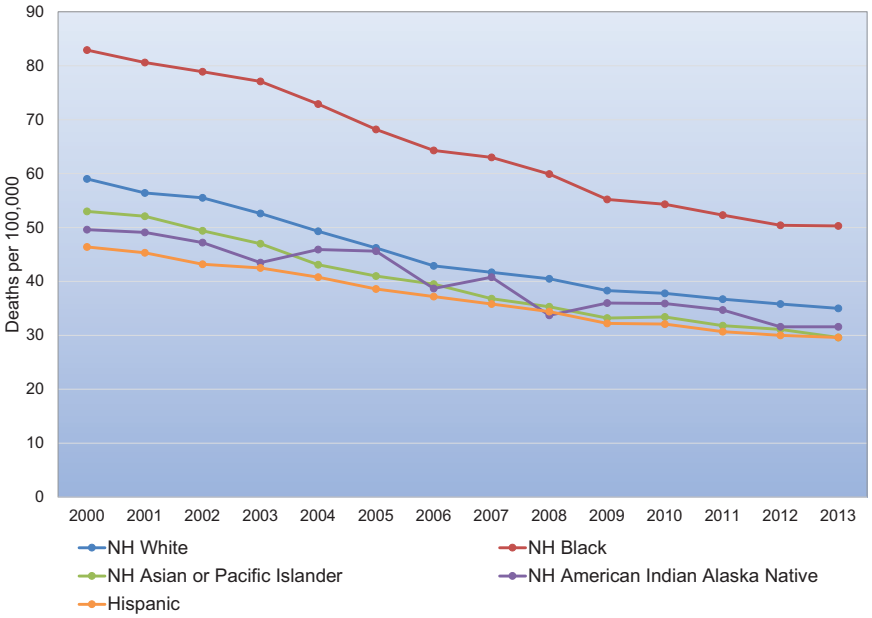

Chart 2-16. US age-standardized death rates* attributable to stroke by race/ethnicity, 2000 to 2013. NH indicates non-Hispanic. *Directly standardized to the age distribution of the 2000 US standard population. Stroke (all cerebrovascular disease): *International Classification of Diseases, 10th Revision* I60 to I69. Source: Centers for Disease Control and Prevention, National Center for Health Statistics.[25]

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3. Smoking/Tobacco Use

See Table 3-1 and Charts 3-1 through 3-6.

Smoking is a major risk factor for CVD and stroke.[1] The AHA has identified never having tried smoking or never having smoked a whole cigarette (for children) and never having smoked or having quit >12 months ago (for adults) as 1 of the 7 components of ideal cardiovascular health.[2] According to NHANES 2011 to 2012 data, 87.1% of adolescents and 77.8% of adults met these criteria.

Prevalence

Youth

(See Charts 3-1 and 3-2.)

- In 2013, for adolescents aged 12 to 17 years[3]:
  - —Among adolescents aged 12 to 17 years, 5.6% reported current cigarette use (respondents were asked, "During the past 30 days, have you smoked part or all of a cigarette?"), 2.3% of adolescents reported current cigar use, and 2.0% of adolescents reported current smokeless tobacco use. Overall, 7.8% of adolescents reported any current tobacco use (NSDUH).
  - —Current cigarette use was similar for male and female adolescents (5.7% and 5.5%, respectively; NSDUH).
  - —Male adolescents were more likely than female adolescents to report current cigar use (3.2% compared with 1.4%) and current smokeless tobacco use (3.4% compared with 0.4%; NSDUH).
  - —Of adolescents who were current smokers (5.6%) in 2013, 19.4% were daily smokers. Adolescents smoking 1 pack of more per day constituted 11.9% of current smokers (NSDUH).
  - —Non-Hispanic white students were more likely than Hispanic or non-Hispanic black students to report any current tobacco use, which includes cigarettes, cigars, or smokeless tobacco (9.9% compared with 4.9% for non-Hispanic black students and 5.5% for Hispanic students; NSDUH).
- Current cigarette use increases sharply when it becomes legal for adolescents at 18 years of age. In 2013, 27.1% of adults aged 18 to 20 years were current smokers compared with 5.6% of adolescents aged 12 to 17 years (NSDUH).[3]
- In most states, the minimum age for purchasing tobacco products is 18 years of age. However, Alabama, Alaska, New Jersey, Utah, New York City, and some other communities have set higher minimum ages. The Institute of Medicine's review of the literature concluded that increasing the minimum age to legally purchase tobacco products would likely prevent or delay tobacco use by adolescents and young adults, especially those aged 15 to 17 years.[4]
- Trends in cigarette smoking tobacco use for adolescents aged 12 to 17 years are as follows (Chart 3-2)[3]:
  - —In the past decade, the percentage of adolescents using tobacco products decreased from 15.2% in 2003 to 7.8% in 2013 (NSDUH).
  - —The percentage who reported current cigarette use declined from 13.0% in 2003 to 5.6% in 2013. This decline was found for both boys (from 12.5% to 5.7%) and girls (from 11.9% to 5.5%) (Chart 3-2) (NSDUH).
  - —Among youths aged 12 to 17 years who had not smoked cigarettes before the past year, the first-time cigarette use rate in 2013 was 4.3%. Declines were found for both boys (down to 4.3% in 2013 from 7.5% in 2003) and girls (down to 4.2% in 2013 from 5.8% in 2003) (NSDUH).

Adults

(See Table 3-1 and Charts 3-2 through 3-5.)

Since the US Surgeon General's first report on the health dangers of smoking, smoking prevalence among adults has been cut in half, from 51% of men smoking in 1965 to 19% in 2014 and from 34% of women in 1965 to 15% in 2014 (Chart 3-3; NHIS). The decline in smoking, along with other factors (including improved treatment and reductions in the prevalence of risk factors such as uncontrolled hypertension and high cholesterol), is a contributing factor in the sharp decline in the HD death rate during this period.[5]

- In 2014, among adults ≥18 years of age[6] (Chart 3-4):
  - —18.8% of men and 15.1% of women were current cigarette smokers (NHIS).
  - —The percentage of current cigarette smokers (16.9%) declined 30% since 1998 (24.1%).
- In 2011 to 2013, 60% of adults ≥18 years of age had never smoked (Health Data Interactive).[7]
- By region, the prevalence of current cigarette smokers was highest in the Midwest (20.5%) and lowest in the West (13.6%).[8]

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Abbreviations Used in Chapter 3

AHA	American Heart Association
AIAN	American Indian or Alaska Native
AMI	acute myocardial infarction
BRFSS	Behavioral Risk Factor Surveillance System
CDC	Centers for Disease Control and Prevention
CHD	coronary heart disease
CI	confidence interval
CVD	cardiovascular disease
DM	diabetes mellitus
HD	heart disease
NH	non-Hispanic
NHANES	National Health and Nutrition Examination Survey
NHIS	National Health Interview Survey
NHOPI	Native Hawaiian or Pacific Islander
NSDUH	National Survey on Drug Use and Health
RR	relative risk
SAH	subarachnoid hemorrhage
SBP	systolic blood pressure
WHO	World Health Organization

- In 2012 to 2013, the states with the highest percentage of current cigarette smokers were West Virginia (32.0%), Kentucky (29.7%), Mississippi (25.9%), Arkansas (25.8%), and Missouri (25.1%), compared with the US average of 17.9% (Chart 3-5; NHIS).[9]
- In 2012 to 2013, the states with the lowest percentage of current cigarette smokers were Utah (10.5%), California (11.4%), New Jersey (12.6%), Hawaii (14.0%), New York (15.0%), and the District of Columbia (13.9%); all percentages were significantly lower than the US average (17.9%) (Chart 3-5; NHIS).[9]
- In 2014, among adults ≥18 years of age, Asian men (13.8%) and Hispanic men (13.8%) were less likely to be current cigarette smokers than American Indian or Alaska Native men (18.6%), non-Hispanic white men (19.9%), and non-Hispanic black men (21.4%), on the basis of age-adjusted estimates (NHIS).[9] Similarly, in 2014, Asian women (5.5%) and Hispanic women (7.4%) were less likely to be current cigarette smokers than non-Hispanic black women (13.4%), non-Hispanic white women (18.3%), and American Indian or Alaska Native women (21.6%; NHIS).[6]
- Current smoking status among 18- to 44-year-old men declined from 26.1% in 2004 to 21.7% in 2014, and for 18- to 44-year-old women, smoking declined from 26.5% to 16.6% over the same time period (NHIS).[6,10]
- On the basis of age-adjusted estimates in 2011 to 2013, among people ≥65 years of age, 9.5% of men and 7.3% of women were current smokers. In this age group, men were more likely than women to be former smokers (52.1% compared with 32.0%) (NHIS).[7]
- Smoking prevalence increases as family income declines. Among adults ≥18 years of age living below the poverty level, 27.8% were current smokers in 2011 to 2013. In comparison, among adults ≥18 years of age living at ≥200% of the poverty level, 15.0% were current smokers (Table 3-1; NHIS).[7]
- Smoking prevalence was higher among adults ≥18 years of age who reported having a disability or activity limitation (23.0%) than among those reporting no disability or limitation (17.0%; NHIS).[11]
- In 2012 to 2013, among women 15 to 44 years of age, past-month cigarette use was lower among those who were pregnant (15.4%) than among those who were not pregnant (24.0%). Rates were higher among women 18 to 25 years of age (21.0% versus 26.2% for pregnant and nonpregnant women, respectively) than among women 26 to 44 years of age (11.8% versus 25.4%, respectively). Smoking declines by pregnancy trimester, from 19.9% of women 15 to 44 years of age in the first trimester of pregnancy to 12.8% in the third trimester (NSDUH).[3]

Incidence

- In 2013[3]:
  - —Approximately 2.1 million people ≥12 years of age smoked cigarettes for the first time within the past 12 months, down from 2.3 million in 2012. The 2012 estimate averages out to ≈5700 new cigarette smokers every day. Half of new smokers (50.5%) in 2013 were <18 years of age when they first smoked cigarettes (NSDUH).
  - —The number of new smokers <18 years of age (1.0 million) was down from 2002 (1.3 million); new smokers ≥18 years of age increased from ≈600 000 in 2002 to 1.0 million in 2013 (NSDUH).
  - —Among people 12 to 49 years of age who had started smoking within the past 12 months, the average age of first cigarette use was 17.8 years, the same as in 2012 (NSDUH).

Morbidity

- A 2010 report of the US Surgeon General on how tobacco causes disease summarized an extensive body of literature on smoking and CVD and the mechanisms through which smoking is thought to cause CVD.[12] There is a sharp increase in CVD risk with low levels of exposure to cigarette smoke, including secondhand smoke, and a less rapid further increase in risk as the number of cigarettes per day increases.
- Smoking is an independent risk factor for CHD and appears to have a multiplicative effect with the other major risk factors for CHD: high serum levels of lipids, untreated hypertension, and DM.[12]
- Cigarette smoking is an independent risk factor for both ischemic stroke and SAH and has a synergistic effect on other stroke risk factors such as SBP[13] and oral contraceptive use.[14,15]
- A meta-analysis comparing pooled data of ≈2.4 million smokers and nonsmokers found the RR ratio of smokers to nonsmokers for developing CHD was 25% higher in women than in men (95% CI, 1.12–1.39).[16]
- A meta-analysis comparing pooled data of ≈3.8 million smokers and nonsmokers found a similar risk of stroke associated with current smoking in women and men.[17]
- Current smokers have a 2 to 4 times increased risk of stroke compared with nonsmokers or those who have quit for >10 years.[18,19]
- Tobacco exposure is a top risk factor for disability in the United States, second only to dietary risks.[20]

Mortality

- In 2010, tobacco smoking was the second-leading risk factor for death in the United States, after dietary risks.[20]
- Smoking was responsible for >480 000 premature deaths in the United States annually from 2005 to 2009 among those ≥35 years of age. Furthermore, almost one third of deaths of CHD are attributable to smoking and secondhand smoke exposure.[5]
- Each year from 2005 to 2009, an estimated 41 000 US deaths were attributable to exposure to secondhand smoke among those ≥35 years of age.[5]
- In 2009, smoking was estimated to cause 3.3 million years of potential life lost for males and 2.2 million years for females, excluding deaths attributable to smoking-attributable residential fires and adult deaths attributable to secondhand smoke.[5]
- Recent analysis found that in addition to the known risk of death attributable to CVD and stroke attributable to smoking, the risk of mortality attributable to hypertensive HD and hypertensive renal disease is related to smoking.[21]
- From 2005 to 2009, smoking during pregnancy resulted in an estimated 970 infant deaths annually.[5]

- On average, male smokers die 13.2 years earlier than male nonsmokers, and female smokers die 14.5 years earlier than female nonsmokers.[1]
- Overall mortality among US smokers is 3 times higher than that for never-smokers.[22]
- If current smoking trends continue, 5.6 million US children will die prematurely during adulthood of smoking.[5]
- Since the first report on the dangers of smoking from the US Surgeon General in 1964, tobacco control efforts have contributed to a reduction of 8 million premature smoking-attributable deaths.[23]

Smoking Cessation

- Smoking cessation reduces the risk of cardiovascular morbidity and mortality for smokers with and without CHD.
  - —There is no convincing evidence to date that reducing the amount smoked by smoking fewer cigarettes per day reduces the risk of CVD, although in several studies a dose-response relationship has been seen among current smokers between the number of cigarettes smoked per day and CVD incidence.[12]
- Quitting smoking at any age significantly lowers mortality from smoking-related diseases, and the risk declines more the longer the time since quitting smoking.[24] Cessation appears to have both short-term (weeks to months) and long-term (years) benefits for lowering CVD risk. Overall, risk appears to approach that of nonsmokers after ≈10 years of cessation.
- Smokers who quit smoking at 25 to 34 years of age gained 10 years of life compared with those who continued to smoke. Those aged 35 to 44 years gained 9 years and those aged 45 to 54 years gained 6 years of life, on average, compared with those who continued to smoke.[22]
- In 2010, 48.3% of adult current smokers ≥18 years of age who had a health checkup during the preceding year reported that they had been advised to quit. Smokers between 18 and 24 (31%) and 24 to 44 (44%) years of age were less likely to be advised to quit than those at older ages (57%; NHIS).[25]
- Cessation medications (including sustained-release bupropion, varenicline, and nicotine gum, lozenge, nasal spray, and patch) are effective for helping smokers quit.[26]
- In addition to medications, smoke-free policies, increases in tobacco prices, cessation advice from healthcare professionals, and quitlines and other counseling have contributed to smoking cessation.[25]
- In 2010, 52.4% of adult smokers reported having tried to quit smoking in the past year; 6.2% reported they had recently quit smoking. Of those who tried to quit smoking, 30.0% used cessation medications.[25]
- The majority of ex-smokers report that they quit without any formal assistance.[27]
- Mass media antismoking campaigns, such as the CDC's Tips campaign (Tips From Former Smokers), have been shown to reduce smoking-attributable morbidity and mortality and are cost-effective.[28]
- Despite states having collected $25.6 billion in 2012 from the 1998 Tobacco Master Settlement Agreement and tobacco taxes, <2% of those funds are spent on tobacco prevention and cessation programs. In addition, progress in passing and raising tobacco taxes and enacting smoke-free laws has slowed.[27]
- In 2014, a major drug store chain, CVS Caremark Corporation, stopped selling tobacco products, a step that may reduce access to tobacco products and therefore encourage some smokers to quit.[29]

Electronic Cigarettes

(See Chart 3-6.)

- Electronic nicotine delivery systems, more commonly called electronic cigarettes or e-cigarettes, are battery-operated devices that deliver nicotine, flavors, and other chemicals to the user in an aerosol. Although e-cigarettes were introduced less than a decade ago, there are currently >450 e-cigarette brands on the market, and sales in the United States were projected to be $2 billion in 2014.[30]
- Because these products have not been well studied, their risks and benefits are not fully understood, although they are thought to have a lower risk of harmful effects than conventional cigarettes.[31,32] Specifically, the health risks from the inhaled nicotine and other chemicals in e-cigarettes are not entirely known.[5,33,34]
- In addition to uncertainty about the harmful effects to users, the risks associated with secondhand exposure to e-cigarettes have not been well studied.[31,32,35]
- E-cigarettes may play a beneficial role in helping smokers reduce or eliminate their conventional cigarette smoking; however, there are concerns that e-cigarettes may be a gateway to nicotine addiction and tobacco use by nonsmokers, especially teenagers, or may promote relapse among former smokers.[5,33,34]
- Teenagers are increasingly trying e-cigarettes. In 2013, 3.0% of middle school students had ever tried e-cigarettes, up from 1.4% in 2011. In 2013, 11.9% of high school students had ever tried e-cigarettes, up from 4.7% in 2011 (Chart 3-6; National Youth Tobacco Survey).[36]
- As of November 30, 2014, 40 states had banned e-cigarettes sales to minors and 3 states prohibited e-cigarette use in private worksites, restaurants, and bars.[37]
- Many public health advocates are worried that e-cigarettes will reverse decades of efforts to denormalize smoking, which contributed to the decline in smoking.[5,33–35]
- The answers to some of these questions may become clearer as the regulatory oversight of e-cigarettes becomes more defined.[5] Currently, only e-cigarettes that are marketed for therapeutic purposes are regulated by the US Food and Drug Administration, but in April 2014, the US Food and Drug Administration proposed extending its tobacco product authorities to include e-cigarettes.[38]

Secondhand Smoke

- Data from the US Surgeon General on the consequences of secondhand smoke indicate the following:
  - —Nonsmokers who are exposed to secondhand smoke at home or at work increase their risk of developing CHD by 25% to 30%.[12]
  - —Short exposures to secondhand smoke can cause blood platelets to become stickier, damage the lining of blood

vessels, and decrease coronary flow velocity reserves, potentially increasing the risk of an AMI.[12]
—Exposure to secondhand smoke increases the risk of stroke by 20% to 30%.[5]
—Nearly 34 000 premature deaths of HD occur each year in the United States among nonsmokers.[5]

- In 2008, data from 11 states showed that the majority of people surveyed in each state reported having smoke-free home rules, ranging from 68.8% in West Virginia to 85.6% in Arizona (BRFSS).[39]
- As of March 2015, 27 states and the District of Columbia had laws that prohibited smoking in indoor areas of worksites, restaurants, and bars; no states had such laws in 2000. As of March 2015, 9 states had no laws banning or restricting areas for smoking in private workplaces.[40]
- In 2012, 30 of the 50 largest US cities prohibited indoor smoking in private workplaces, either through state or local ordinances.[41]
- Pooled data from 17 studies in North America, Europe, and Australasia suggest that smoke-free legislation can reduce the incidence of acute coronary events by 10%.[42]
- The percentage of the US nonsmoking population with serum cotinine ≥0.05 ng/mL (which indicates exposure to secondhand smoke) declined from 52.5% in 1999 to 2000 to 25.3% in 2011 to 2012, with declines occurring for both children and adults. During 2011 to 2012, the percentage of nonsmokers with detectable serum cotinine was 40.6% for those 3 to 11 years of age, 33.8% for those 12 to 19 years of age, and 21.3% for those ≥20 years of age. The percentage was also higher for non-Hispanic blacks (46.8%) than for non-Hispanic whites (21.8%) and Mexican Americans (23.9%). People living below the poverty level (43.2%) and those living in rental housing (36.8%) had higher rates of secondhand smoke exposure than their counterparts (21.1% of those living above the poverty level and 19.0% of those who owned their homes; NHANES).[8]

Cost

- Each year from 2005 to 2009, US smoking-attributable economic costs were between $289 billion and $333 billion, including $133 billion to $176 billion for direct medical care of adults and $151 billion for lost productivity related to premature death.[5]
- In the United States, cigarette smoking is associated with 9% of annual aggregated healthcare spending.[43]
- In 2008, $9.94 billion was spent on marketing cigarettes in the United States.[44]
- Cigarette prices in the United States have increased 283% between the early 1980s and 2011, in large part because of excise taxes on tobacco products. Higher taxes have decreased cigarette consumption, which fell from ≈30 million packs sold in 1982 to ≈14 million packs sold in 2011.[44]

Global Burden of Smoking

- Although tobacco use in the United States has been declining, tobacco use worldwide has climbed steeply and is currently responsible for 5 million deaths annually.[45]
- Worldwide, tobacco smoking (including secondhand smoke) was 1 of the top 3 leading risk factors for disease and contributed to an estimated 6.2 million deaths in 2010.[46]
- To help combat the global problem of tobacco exposure, in 2003 the WHO adopted the Framework Convention on Tobacco Control treaty. The WHO Framework Convention on Tobacco Control contains a set of universal standards to limit tobacco supply and demand worldwide. These standards include the use of tax policies to reduce tobacco consumption, a ban on the indoor use of tobacco products, implementation of educational programs about the dangers of tobacco use, and restrictions of the sale of tobacco products to international travelers. Since it came into force in 2005, 180 countries have ratified the WHO Framework Convention on Tobacco Control.[47]

Table 3-1. Cigarette Smoking

Population Group	Prevalence, 2014 (Age ≥18 y*[48])	Cost[5]
Both sexes	43 904 000 (16.9%)	$289 Billion per year
Males	24 348 000 (18.8%)	…
Females	19 518 000 (15.1%)	…
NH white males	19.9%	…
NH white females	18.3%	…
NH black males	21.4%	…
NH black females	13.4%	…
Hispanic or Latino males	13.8%	…
Hispanic or Latino females	7.4%	…
Asian-only males	13.8%	
Asian-only females	5.5%	…
American Indian/Alaska Native–only males	18.6%	
American Indian/Alaska Native–only females	21.6%	…
Living at <100% of poverty level†	27.8%	…
Living at 100%–199% of poverty level†	23.6%	…
Living at ≥200% of poverty level†	15.0%	…

Percentages are age adjusted. Estimates for Asian-only and American Indian/Alaska Native–only include non-Hispanic and Hispanic people. Ellipses (…) indicate data not available; and NH, non-Hispanic.

*Rounded to the nearest thousand; based on total resident population.

†Estimates are for 2011 to 2013.

Data derived from the National Center for Health Statistics, National Health Interview Survey, Health Data Interactive.[7]

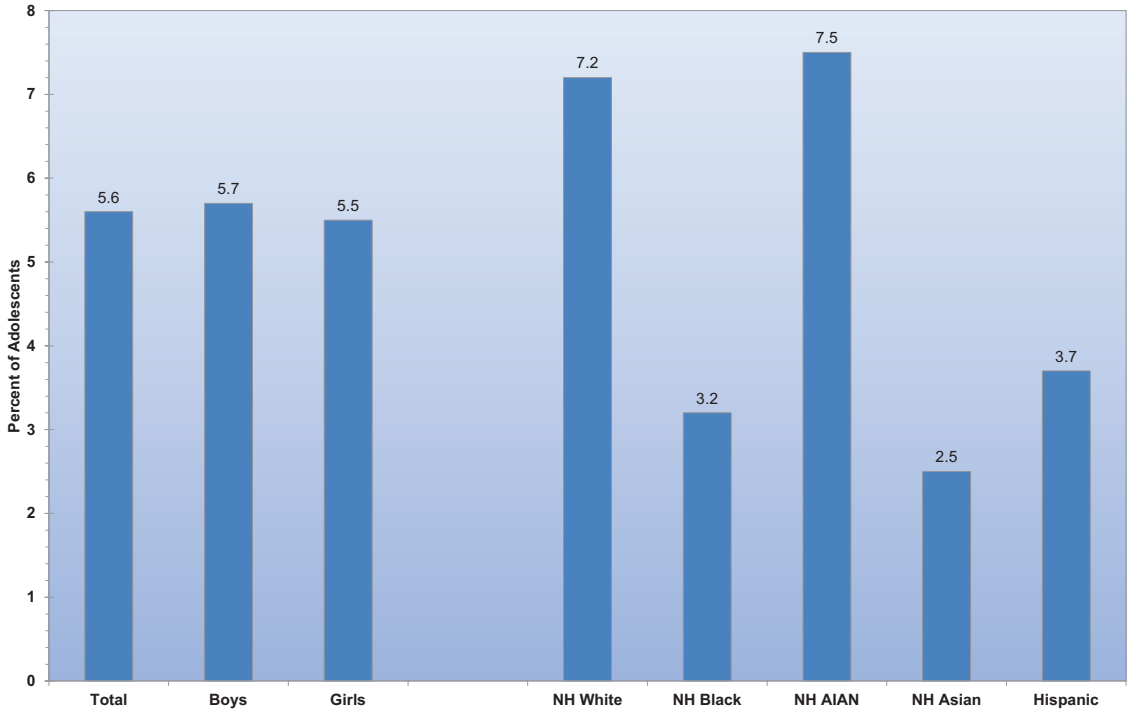

Chart 3-1. Prevalence (%) of current cigarette smoking for adolescents aged 12 to 17 years by sex and race/ethnicity (National Survey on Drug Use and Health [NSDUH], 2013). Because of methodological differences among the NSDUH, the Youth Risk Behavior Survey, the National Youth Tobacco Survey, and other surveys, percentages of cigarette smoking measured by these surveys are not directly comparable. Notably, school-based surveys may include students who are 18 years old, who are legally permitted to smoke and have higher rates of smoking. AIAN indicates American Indian or Alaska Native; and NH, non-Hispanic. Data derived from Substance Abuse and Mental Health Services Administration, National Survey on Drug Use and Health.[3]

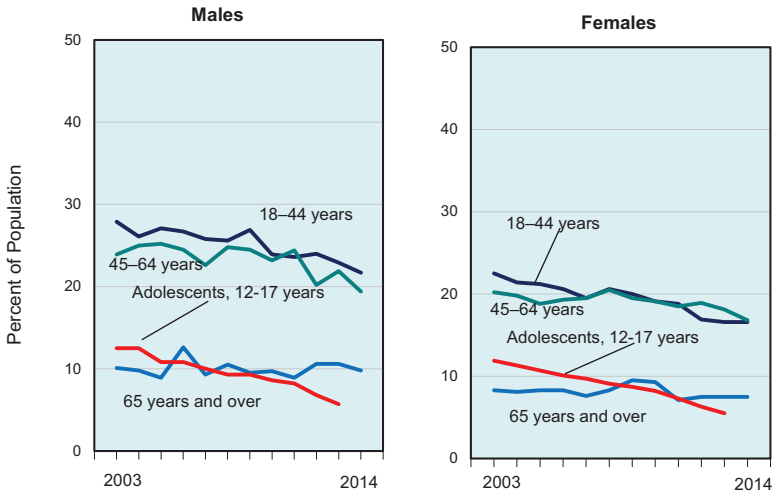

Chart 3-2. Prevalence (%) of current cigarette smoking for adolescents and adults by sex and age (National Health Interview Survey, 2003–2014; National Survey on Drug Use and Health [NSDUH], 2003–2013). Data derived from the Centers for Disease Control and Prevention/National Center for Health Statistics and the Substance Abuse and Mental Health Services Administration (NSDUH).[3,6]

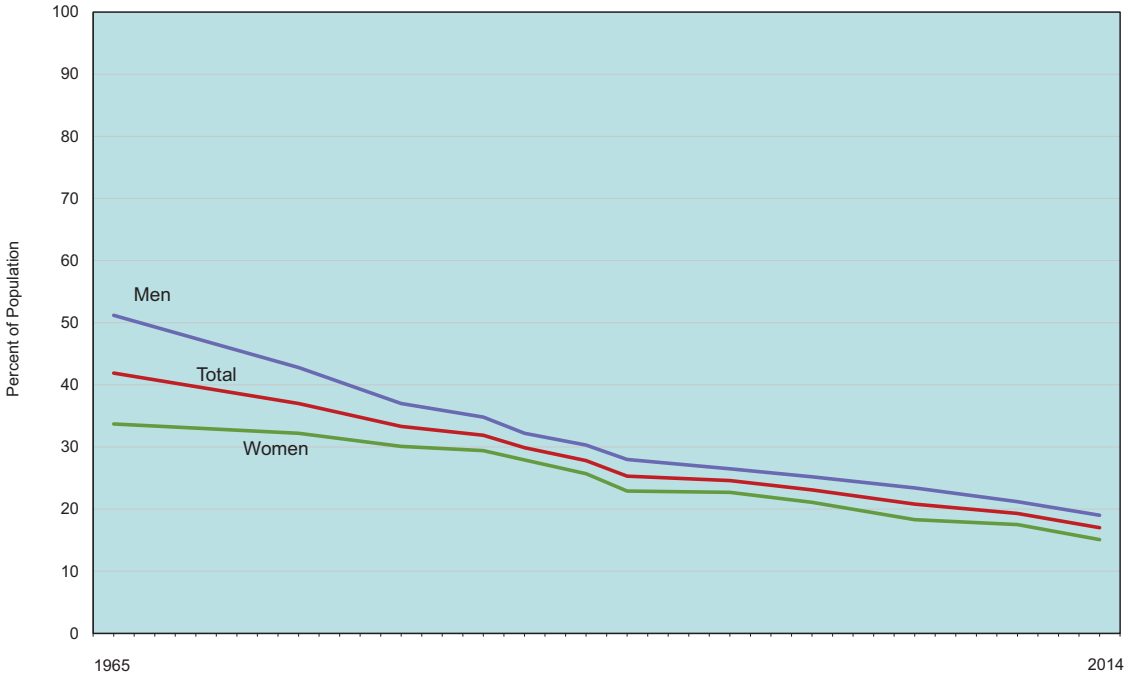

Chart 3-3. Long-term trend in current cigarette smoking prevalence (%) for adults ≥18 years of age by sex (National Health Interview Survey [NHIS], 1965–2014, selected years). Data derived from the Centers for Disease Control and Prevention/National Center for Health Statistics, *Health, United States, 2014* (NHIS).[48]

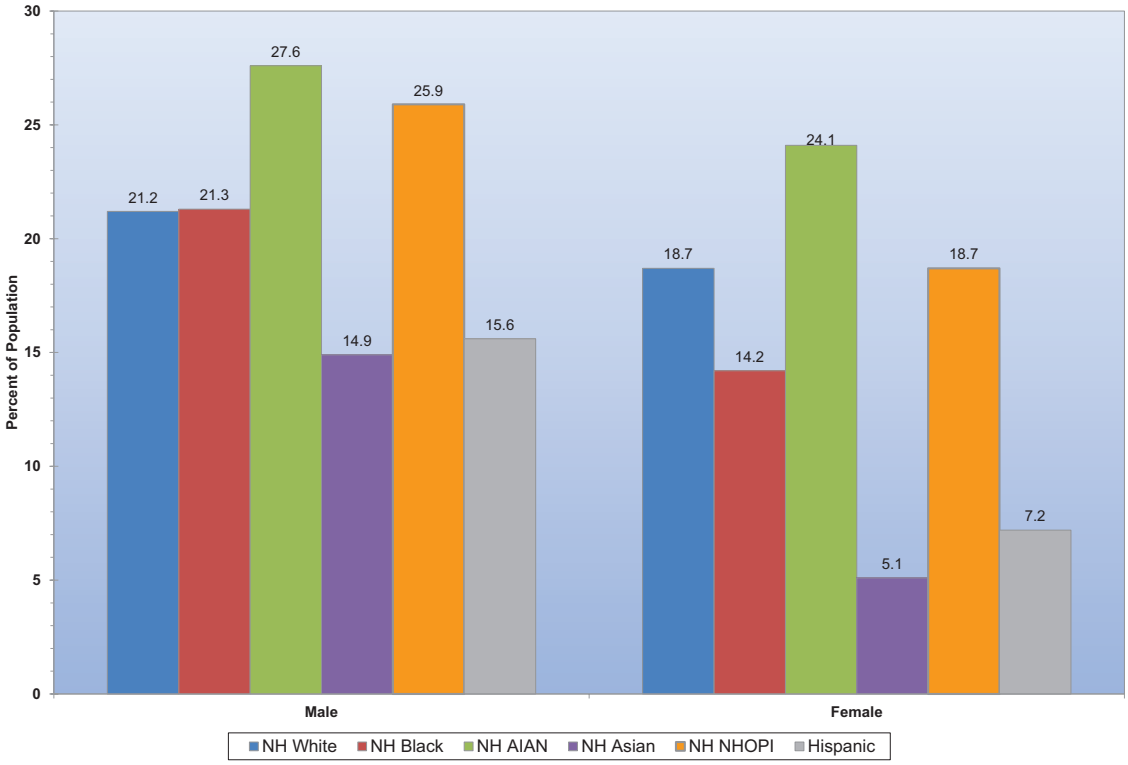

Chart 3-4. Prevalence (%) of current cigarette smoking for adults ≥18 years of age by sex and race/ethnicity (National Health Interview Survey [NHIS], 2012–2014). All percentages are age adjusted. AIAN indicates American Indian/Alaska Native; NH, non-Hispanic; and NHOPI, Native Hawaiian or Pacific Islander. Data derived from Centers for Disease Control and Prevention/National Center for Health Statistics, NHIS.[6]

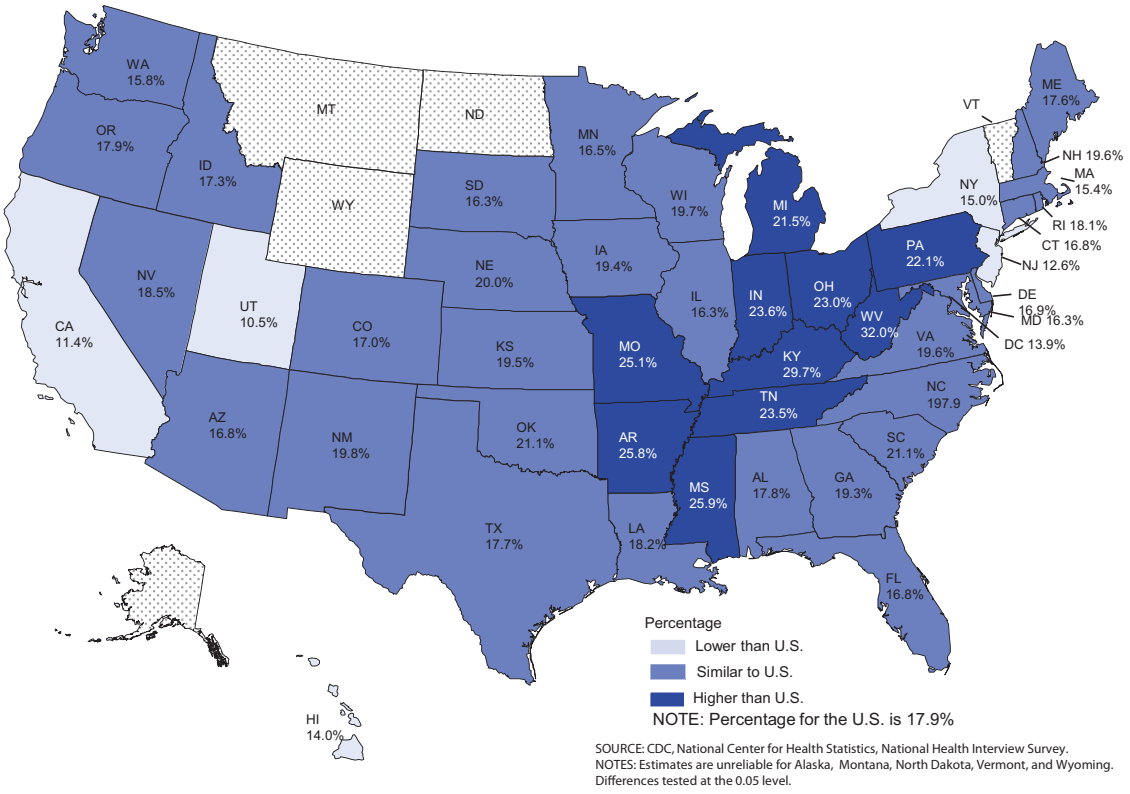

Chart 3-5. Prevalence (%) of current cigarette smoking for adults ≥18 years of age, by state: United States (National Health Interview Survey [NHIS], 2012–2013). Percentages are average annual prevalences. Data derived from the Centers for Disease Control and Prevention/National Center for Health Statistics (NHIS).[9]

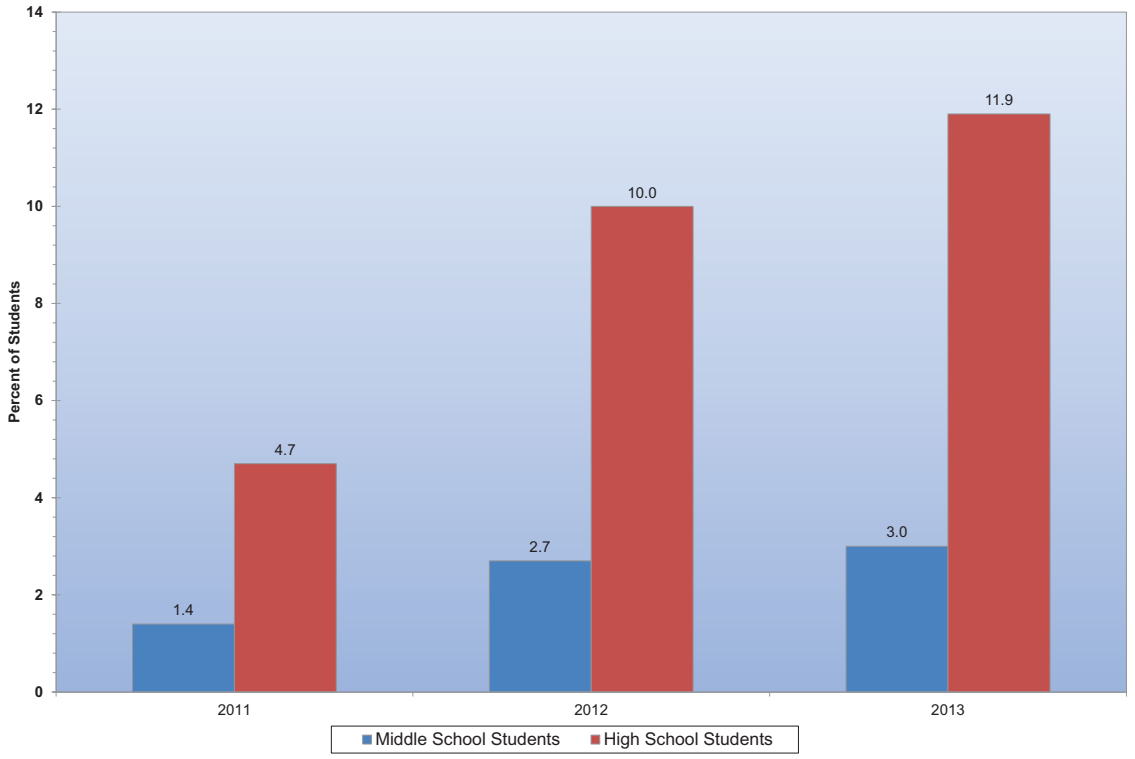

Chart 3-6. Percentage (%) of students who have ever tried electronic cigarettes by school level (National Youth Tobacco Survey, 2011–2013). Data derived from the Centers for Disease Control, National Youth Tobacco Survey.[36]

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4. Physical Inactivity

See Table 4-1 and Charts 4-1 through 4-5.

Physical inactivity is a major risk factor for CVD and stroke.[1] Meeting the guidelines for PA is 1 of the AHA's 7 components of ideal cardiovascular health for both children and adults.[2] The AHA and 2008 federal guidelines on PA recommend that children get at least 60 minutes of PA daily (including aerobic and muscle- and bone-strengthening activity). The guidelines recommend that adults get at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic activity (or an equivalent combination) per week and perform muscle-strengthening activities at least 2 days per week (US Department of Health and Human Services). In 2011 to 2012, on the basis of survey interviews, 36.5% of children and 44.0% of adults met these criteria.

Not only does being physically active improve health, but being inactive is unhealthy.[3] PA reduces premature mortality. In addition, PA improves risk factors for CVD (such as HBP and high cholesterol) and reduces the likelihood of diseases related to CVD, including CHD, stroke, type 2 DM, and sudden heart attacks (US Department of Health and Human Services). Benefits from PA are seen for all ages and groups, including older adults, pregnant women, and people with disabilities and chronic conditions. Therefore, the federal guidelines recommend being as physically active as abilities and conditions allow and increasing PA gradually.

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Abbreviations Used in Chapter 4

AHA	American Heart Association
BMI	body mass index
BNP	B-type natriuretic peptide
CARDIA	Coronary Artery Risk Development in Young Adults
CHD	coronary heart disease
CI	confidence interval
CRP	C-reactive protein
CVD	cardiovascular disease
DBP	diastolic blood pressure
DM	diabetes mellitus
EF	ejection fraction
EPIC-Norfolk	European Prospective Investigation Into Cancer and Nutrition—Norfolk Cohort
FMD	flow-mediated dilation
HbA_{1c}	hemoglobin A_{1c}
HBP	high blood pressure
HDL-C	high-density lipoprotein cholesterol
HF	heart failure
HR	hazard ratio
LDL-C	low-density lipoprotein cholesterol
LV	left ventricular
MI	myocardial infarction
NAVIGATOR	A Multinational, Randomized, Double-Blind, Placebo-Controlled, Forced-Titration, 2 × 2 Factorial Design Study of the Efficacy and Safety of Long-Term Administration of Nateglinide and Valsartan in the Prevention of Diabetes and Cardiovascular Outcomes in Subjects With Impaired Glucose Tolerance (IGT)
NH	non-Hispanic
NHANES	National Health and Nutrition Examination Survey
NHIS	National Health Interview Survey
PA	physical activity
PAD	peripheral artery disease
PAR	population attributable risk
RCT	randomized controlled trial
RR	relative risk
SBP	systolic blood pressure
SD	standard deviation
TC	total cholesterol
WHI	Women's Health Initiative
WHO	World Health Organization
YRBSS	Youth Risk Behavior Surveillance System

Defining PA

There are 4 dimensions of PA (mode or type, frequency, duration, and intensity) and 4 common domains (occupational, domestic, transportation, and leisure time). Historically, recommendations on PA for health purposes have focused on leisure-time activity. However, because all domains of PA could have an impact on health, and because an increase in 1 domain may sometimes be compensated for by a decrease in another domain, it is important to generate data on all dimensions and domains of PA.

There are 2 broad categories of methods to assess PA: (1) subjective methods that use questionnaires and diaries/logs and (2) objective methods that use wearable monitors (pedometers, accelerometers, etc). It is very important to keep in mind that the bulk of the data available linking inactivity/PA to cardiovascular outcomes has been obtained with the use of questionnaires. Thus, prevalence data on inactivity/PA must be interpreted with an understanding of the limitations of the tools that have been used to generate such data. Although any activity is better than none, the federal guidelines specify the suggested frequency, duration, and intensity of activity.

Studies that used both subjective methods (respondent reported) and objective methods (such as wearable monitors, like pedometers or accelerometers) have found that there is marked discordance between reported and measured PA, with respondents often overstating their PA, especially the intensity.[4,5] Furthermore, surveys often ask only about leisure-time PA; however, PA also may come from occupational, domestic, and transportation responsibilities. People who get a lot of PA from these other responsibilities may be less like to engage in leisure-time PA, and yet they may meet the federal PA guidelines.

PA is the most commonly reported indicator for physical fitness; however, chronic physical inactivity contributes to a poor level of cardiorespiratory (or aerobic) fitness, which is a stronger predictor of adverse cardiometabolic and cardiovascular outcomes than traditional risk factors. Although both PA and cardiorespiratory fitness are inversely related to the risk of CVD and other clinical outcomes, they are in part distinct

measures in the assessment of CVD risk.[6] PA is a behavior that can potentially improve cardiorespiratory fitness. Although many studies have shown that increasing the amount and quality of PA can improve cardiorespiratory fitness, other factors can contribute, such as a genetic predisposition to perform aerobic exercise.[7] Because cardiorespiratory fitness is directly measured and reflects both participation in PA and the state of physiological systems affecting performance, the relationship between cardiorespiratory fitness and clinical outcomes is stronger than the relationship of PA to a series of clinical outcomes.[6] Unlike health behaviors such as PA and risk factors that are tracked by federally funded programs, there are no national data on cardiorespiratory fitness, and the development of a national cardiorespiratory fitness registry has been proposed.[6] Such additional data on the cardiorespiratory fitness levels of Americans may give a fuller and more accurate picture of physical fitness levels.[6]

Prevalence

Youth

Inactivity

(See Chart 4-1.)

In 2013 (YRBSS)[8]:

- Nationwide, 15.2% of adolescents reported that they were inactive on all of the previous 7 days (that is, they did not participate in ≥60 minutes of any kind of PA that increased their heart rate and made them breathe hard on any 1 of the previous 7 days).
- Girls were more likely than boys to report inactivity (19.2% versus 11.2%).
- The prevalence of inactivity was highest among non-Hispanic black (27.3%) and Hispanic (20.3%) girls, followed by non-Hispanic white girls (16.1%), non-Hispanic black boys (15.2%), Hispanic boys (12.1%), and non-Hispanic white boys (9.2%).

Activity Recommendations

(See Chart 4-2.)

- In 2013 (YRBSS)[8]:
  - —The proportion of high school students who met activity recommendations of ≥60 minutes of PA on all 7 days of the week was 27.1% nationwide and declined from 9th (30.4%) to 12th (24.3%) grades. At each grade level, the proportion was higher in boys than in girls.
  - —More than double the percentage of high school boys (36.6%) than girls (17.7%) reported having been physically active ≥60 minutes per day on all 7 days.
  - —The proportion of students who participated in muscle-strengthening activities on ≥3 days of the week was 51.7% nationwide and declined from 9th (54.8%) to 12th (47.7%) grades. At each grade level, the proportion was higher in boys than in girls.
  - —More high school boys (61.8%) than girls (41.6%) reported having participated in muscle-strengthening activities on ≥3 days of the week.
- On the basis of accelerometer counts per minute >2020, 42% of 6- to 11-year-olds accumulated ≥260 minutes of moderate to vigorous PA on ≥5 days per week, whereas only 8% of 12- to 15-year-olds and 7.6% of 16- to 19-year-olds achieved similar activity levels.[4]
- More boys than girls met PA recommendations (≥60 minutes of moderate to vigorous activity on most days of the week) as measured by accelerometry.[4]

Television/Video/Computers

(See Chart 4-3.)

Research suggests that screen time (watching television or using a computer) may lead to less PA among children.[9] In addition to a negative association with PA time, television viewing time is associated with poor nutritional choices, overeating, and weight gain (refer to Chapter 5, Nutrition).

- In 2013 (YRBSS)[8]:
  - —Nationwide, 41.3% of adolescents used a computer for activities other than school work (eg, videogames or other computer games) for ≥3 hours per day on an average school day.
  - —The prevalence of using computers ≥3 hours per day was highest among non-Hispanic black boys (51.9%) and non-Hispanic black girls (46.6%), followed by Hispanic girls (44.8%), Hispanic boys (42.0%), non-Hispanic white boys (39.1%), and non-Hispanic white girls (35.6%).
  - —32.5% of adolescents watched television for ≥3 hours per day.
  - —The prevalence of watching television ≥3 hours per day was highest among non-Hispanic black boys (55.3%) and girls (52.2%), followed by Hispanic girls (39.0%) and boys (36.5%) and non-Hispanic white boys (25.7%) and girls (24.3%).

Structured Activity Participation

- Despite recommendations from the National Association for Sport and Physical Education that schools should require daily physical education for students in kindergarten through 12th grade,[10] only 29.4% of students attended physical education classes in school daily (34.9% of boys and 24.0% of girls) (YRBSS).[8]
- Daily physical education class participation declined from the 9th grade (47.8% for boys, 36.5% for girls) through the 12th grade (24.4% for boys, 16.1% for girls) (YRBSS).[8]
- Little more than half (54.0%) of high school students played on at least 1 school or community sports team in the previous year: 48.5% of girls and 59.6% of boys (YRBSS).[8]

Adults

Inactivity

- According to 2014 data from the NHIS, of adults ≥18 years of age[11]:
  - —30.2% do not engage in leisure-time PA ("no leisure-time PA/inactivity" refers to no sessions of light/moderate or vigorous PA of ≥10 minutes' duration).
  - —Inactivity was higher among women than men (28.5% versus 31.7%, age adjusted) and increased with age from 24.8% (ages 18–44 years) to 32.7% (ages 45–64 years), 35.2% (ages 65–74 years), and 51.1% (≥75 years of age).
  - —Hispanic and non-Hispanic black adults were more likely to be inactive (40.1% and 38.3%, respectively)

than were non-Hispanic white adults (26.3%) on the basis of age-adjusted estimates.

Activity Recommendations

(See Table 4-1 and Chart 4-4.)

- According to 2014 data from the NHIS, of adults ≥18 years of age[11]:
  - —21.4% met the 2008 federal PA guidelines for both aerobic and strengthening activity, an important component of overall physical fitness, based on leisure-time activity.
  - —The age-adjusted proportion who reported engaging in moderate or vigorous leisure-time PA who met the 2008 aerobic PA guidelines for Americans (≥150 minutes of moderate PA or 75 minutes of vigorous PA or an equivalent combination each week) was 50.0%, with 53.2% of men and 47.0% of women meeting the recommendations. Age-adjusted prevalence was 53.5% for non-Hispanic whites, 43.5% for non-Hispanic blacks, and 41.3% for Hispanics.
  - —The proportion of respondents who did not meet the federal aerobic PA guidelines increased with age from 43.3% of 18- to 44-year-olds to 71.8% of noninstitutionalized adults ≥75 years of age.
  - —Education was positively associated with meeting the federal guidelines. Among adults ≥25 years of age, 66.8% of participants with no high school diploma, 57.2% of those with a high school diploma or a high school equivalency credential, 46.9% of those with some college, and 35.0% of those with a bachelor's degree or higher did not meet the full (aerobic and muscle-strengthening) federal PA guidelines.
- The proportion of adults reporting levels of PA that meet the 2008 Physical Activity Guidelines for Americans remains low and decreases with age.[12,13] Thirty-three percent of respondents in a study examining awareness of current US PA guidelines had direct knowledge of the recommended dosage of PA (ie, frequency/duration).[14]
- The percentage of adults reporting ≥150 minutes of moderate PA or 75 minutes of vigorous aerobic PA or an equivalent combination weekly decreased with age from 56.9% for adults 18 to 44 years of age to 27.4% for those ≥75 years of age, on the basis of the 2013 NHIS.[15]
- The percentage of men who engaged in both leisure-time aerobic and strengthening activities decreased with age, from 39.8% at age 18 to 24 years to 11.1% at ≥75 years of age. The percentage of women who engaged in both leisure-time aerobic and strengthening activities also decreased with age, from 20.7% at age 18 to 24 years to 5.3% at ≥75 years of age, on the basis of the 2011 NHIS.[13]
- Using PA recommendations that existed at the time of the survey, adherence to PA recommendations was much lower when based on PA measured by accelerometer in NHANES 2003 to 2004[4]:
  - —Among adults 20 to 59 years of age, 3.8% of men and 3.2% of women met recommendations to engage in moderate to vigorous PA (accelerometer counts >2020/min) for 30 minutes (in sessions of ≥10 minutes) on ≥5 of 7 days.
  - —Among those ≥60 years of age, adherence was 2.5% in men and 2.3% in women.
- Accelerometry data from NHANES 2003 to 2006 showed that men engaged in 35 minutes of moderate activity per day, whereas for women, it was 21 minutes. More than 75% of moderate activity was accumulated in 1-minute bouts. Levels of activity declined sharply after the age of 50 years in all groups.[16]
- In a review examining self-reported versus actual measured PA (eg, accelerometers, pedometers, indirect calorimetry, doubly labeled water, heart rate monitor), 60% of respondents self-reported higher values of activity than what was measured by use of direct methods.[17]
- Among men, self-reported PA was 44% greater than actual measured values; among women, self-reported activity was 138% greater than actual measured PA.[17]
- The discrepancy between reported versus measured PA activity clearly indicates that the proportion of sufficiently active individuals is overestimated and that there is a need to monitor nationwide levels of measured PA.

Trends

Youth

(See Chart 4-5.)

- In 2013 (YRBSS)[8]:
  - —Among students nationwide, there was a significant increase in the prevalence of having participated in muscle-strengthening activities on ≥3 days per week, from 47.8% in 1991 to 51.7%; however, the prevalence decreased from 2011 (55.6%) to 2013 (51.7%).
  - —A significant increase occurred in the prevalence of having used computers for ≥3 hours per day compared with 2003 (22.1% versus 41.3%). The prevalence increased from 2003 to 2009 (22.1% versus 24.9%) and then increased more rapidly from 2009 to 2013 (24.9% versus 41.3%). Even more recently, the prevalence increased to 31.1% in 2011.
  - —Among adolescents nationwide, the prevalence of attending physical education classes at least once per week was steady from 1995 (35.4%) to 2013 (29.4%).
  - —The prevalence of adolescents playing ≥1 team sport in the past year decreased from 58.4% in 2011 to 54.0%.
- In 2012, the prevalence of adolescents aged 12 to 15 years with adequate levels of cardiorespiratory fitness (based on age- and sex-specific standards) was 42.2% in 2012, down from 52.4% in 1999 to 2000.[18]

Adults

- Between 1988 to 1994 and 2001 to 2006 (NHANES), the percentage of adults who reported engaging in >12 bouts of PA per month declined from 57.0% to 43.3% in men and from 49.0% to 43.3% in women (crude percentages).[19]
- The proportion of US adults who meet criteria for muscle strength has improved between 1998 and 2011. Annual estimates of the percentage of US adults who met the muscle-strengthening criteria increased from 17.7% in

1998 to 24.5% in 2011, and estimates of the percentage who met both the muscle-strengthening and aerobic criteria increased from 14.4% in 1998 to 21.0% in 2011.[12,20]
- A 2.3% decline in physical inactivity between 1980 and 2000 was estimated to have prevented or postponed ≈17 445 deaths (≈5%) attributable to CHD in the United States.[21]

CVD and Metabolic Risk Factors

Youth

- Total and vigorous PA are inversely correlated with body fat and the prevalence of obesity.[22]
- Among children 4 to 18 years of age, increased time in moderate to vigorous PA was associated with improvements in waist circumference, SBP, fasting triglycerides, HDL-C, and insulin. These findings were significant regardless of the amount of the children's sedentary time.[23]
- Among children aged 4 to 18 years, both higher activity levels and lower sedentary time measured by accelerometry were associated with more favorable metabolic risk factor profiles.[23]

Adults

- Participants in the Diabetes Prevention Program randomized trial who met the PA goal of 150 minutes of PA per week were 44% less likely to develop DM after 3.2 years of follow-up, even if they did not meet the weight-loss target.[24]
- A review of the US Preventive Services Task Force recommendations examined the evidence on whether relevant counseling interventions for a healthful diet and PA in primary care modify self-reported behaviors, intermediate physiological outcomes, DM incidence, and cardiovascular morbidity or mortality in adults with CVD risk factors. It was concluded that after 12 to 24 months, intensive lifestyle counseling for individuals selected because of risk factors reduced TC by an average of 0.12 mmol/L, LDL-C levels by 0.09 mmol/L, SBP by 2.03 mm Hg, DBP by 1.38 mm Hg, fasting glucose by 0.12 mmol/L, DM incidence by an RR of 0.58, and weight outcomes by a standardized difference of 0.25.[25]
- Weight loss from increased physical exercise, without dietary interventions, was associated with significant reductions in DBP (–2 mm Hg; 95% CI, –4 to –1 mm Hg), triglycerides (–0.2 mmol/L; 95% CI, –0.3 to –0.1 mmol/L), and fasting glucose (–0.2 mmol/L; 95% CI, –0.3 to –0.1 mmol/L).[26]
- A total of 120 to 150 minutes per week of moderate-intensity activity, compared with none, can reduce the risk of developing metabolic syndrome.[27]
- In CARDIA, women who maintained high PA through young adulthood gained 6.1 fewer kilograms of weight and 3.8 fewer centimeters in waist circumference in middle age than those with lower activity. Highly active men gained 2.6 fewer kilograms and 3.1 fewer centimeters than their lower-activity counterparts.[28]
- Self-reported low lifetime recreational activity has been associated with increased PAD.[29]
- In 3 US cohort studies, men and women who increased their PA over time gained less weight in the long term, whereas those who decreased their PA over time gained more weight and those who maintained their current PA had intermediate weight gain.[30]
- Among US men and women, every hour per day of increased television watching was associated with 0.3 lb of greater weight gain every 4 years, whereas every hour per day of decreased television watching was associated with a similar amount of relative weight loss.[30]
- In a sample of 466 605 participants in the China Kadoorie Biobank study, a 1-SD (1.5 h/d) increase in sedentary time was associated with a 0.19-unit higher BMI, a 0.57-cm larger waist circumference, and 0.44% more body fat. Both sedentary leisure time and lower PA were independently associated with an increased BMI.[31]

Morbidity and Mortality

- Physical inactivity is responsible for 12.2% of the global burden of MI after accounting for other CVD risk factors such as cigarette smoking, DM, hypertension, abdominal obesity, lipid profile, no alcohol intake, and psychosocial factors.[32]
- In a meta-analysis of longitudinal studies among women, RRs of incident CHD were 0.83 (95% CI, 0.69–0.99), 0.77 (95% CI, 0.64–0.92), 0.72 (95% CI, 0.59–0.87), and 0.57 (95% CI, 0.41–0.79) across increasing quintiles of PA compared with the lowest quintile.[33]
- A 2003 meta-analysis of 23 studies on the association of PA with stroke indicated that compared with low levels of activity, high (RR, 0.79; 95% CI, 0.69–0.91) and moderate (RR, 0.91; 95% CI, 0.80–1.05) levels of activity were inversely associated with the likelihood of developing total stroke (ischemic and hemorrhagic).[34]
- With television watching as a sedentary activity, 2 hours of television per day is associated with an RR for type 2 DM of 1.20 (95% CI, 1.14–1.27), an RR for fatal or nonfatal CVD of 1.15 (95% CI, 1.06–1.23), and an RR for all-cause mortality of 1.13 (95% CI, 1.07–1.18). The risk for all-cause mortality further increases with >3 hours of television daily.[35]
- Longitudinal studies commonly report a graded, inverse association of PA amount and duration (ie, dosage) with incident CHD and stroke.[36]
- The PA guidelines for adults cite evidence that ≈150 minutes per week of moderate-intensity aerobic activity, compared with none, can reduce the risk of CVD.[37]
- Adherence to PA guidelines for both aerobic and muscle-strengthening activities is associated with 27% lower all-cause mortality among adults without existing chronic conditions such as DM, cancer, MI, angina, CVD, stroke, or respiratory diseases and with 46% lower mortality among people with chronic comorbidities.[37]
- In the Health Professionals Follow-Up Study, for every 3-hour-per-week increase in vigorous-intensity activity, the multivariate RR of MI was 0.78 (95% CI, 0.61–0.98) for men. This 22% reduction of risk can be explained in part by beneficial effects of PA on HDL-C, vitamin D, apolipoprotein B, and HbA_{1c}.[38]
- In a 20-year study of older male veterans, an inverse, graded, and independent association between impaired exercise capacity and all-cause mortality risk was found.

For each increase of 1 metabolic equivalent task in exercise capacity, mortality risk was 12% lower (HR, 0.88; 95% CI, 0.86–0.90). Unfit individuals who improved their fitness status had a 35% lower mortality risk (HR, 0.65; 95% CI, 0.46–0.93) than those who remained unfit.[39]

- In the Cooper Center Longitudinal Study, an analysis conducted on 16 533 participants revealed that across all risk factor strata, the presence of low cardiorespiratory fitness was associated with a greater risk of CVD death over a mean follow-up of 28 years.[40]
- In the Southern Community Cohort Study, which involved 63 308 individuals (with a large proportion of black adults) followed up for >6.4 years, more time spent being sedentary (>12 h/d versus <5.76 h/d) was associated with a 20% to 25% increased risk of all-cause mortality in blacks and whites. Both PA (beneficial) and sedentary time (detrimental) were associated with mortality risk.[41]
- In a study involving 55 137 adults followed up over an average of 15 years, running even 5 to 10 min/d and at slow speeds (<6 mph) was associated with a markedly reduced risk of death attributable to all causes and CVD. This study provides evidence that even a minimal amount of exercise may lower mortality.[42]
- In a study involving 1.1 million women without prior vascular disease and followed up over an average period of 9 years, those who reported moderate activity were found to be at lower risk of CHD, a cardiovascular event, or a first thrombotic event. However, strenuous PA was not found to be as beneficial as moderate PA. These results suggest that although PA reduces risk of CVD, strenuous PA is not more beneficial than moderate PA.[43]
- A population-based cohort from New South Wales in Australia involving 204 542 adults followed up for an average of 6.5 years examined the issue of vigorous PA after control for total moderate to vigorous PA. Compared with those who reported no moderate to vigorous PA, the adjusted HRs for all-cause mortality were 0.66, 0.53, and 0.46 for reporting 10 to 149, 150 to 299, and ≥300 min/wk of activity, respectively. Among those who reported any moderate to vigorous PA, the proportion of vigorous activity showed an inverse dose-response relationship with all-cause mortality compared with those reporting no vigorous activity. Thus, this study indicates that among people reporting any activity, the proportion of vigorous activity is negatively related to mortality, which suggests that vigorous activities should also be recommended to maximize the population benefits of PA.[44]
- An analysis of pooled data from 6 studies in the National Cancer Institute Cohort Consortium involving 661 137 men and women followed up for an average of 14.2 years revealed that compared with individuals reporting no leisure-time PA, an inverse dose-response relationship was observed between level of leisure-time PA (HR=0.80 for less than the recommended minimum of the PA guidelines, HR=0.69 for 1 to 2 times the recommended minimum, HR=0.63 for 2 to 3 times the minimum) and mortality, with the upper threshold for mortality benefit occurring at 3 to 5 times the PA recommendations, with an HR of 0.61. Furthermore, there was no evidence of harm associated with performing ≥10 times the recommended minimum (HR, 0.69). Thus, meeting the 2008 Physical Activity Guidelines for Americans minimum by either moderate- or vigorous-intensity activities was essentially associated with a nearly optimal reduction in mortality risk. This study supports the view that although healthcare professionals should encourage inactive individuals to become physically active, they should not discourage adults who are already very active at levels far above those recommended by the guidelines.[45]
- In a large clinical trial (NAVIGATOR) involving 9306 individuals with impaired glucose tolerance, ambulatory activity assessed by pedometer at baseline and 12 months was found to be inversely associated with risk of a cardiovascular event. Furthermore, changes in ambulatory activity were also inversely associated with the risk of a cardiovascular event. These results show the clinical relevance of assessing or targeting the number of steps taken per day in high-risk patients.[46]
- In the EPIC-Norfolk study, men and women with abdominal obesity with features of the metabolic syndrome who reported themselves to be physically very active were characterized by a lower (≈50%) risk of CHD than sedentary abdominally obese subjects with the metabolic syndrome.[47]
- In the WHI observational study (n=71 018), sitting for ≥10 h/d compared with ≤5 h/d was associated with increased CVD risk (HR, 1.18) in multivariable models that included PA. Low PA was also associated with higher CVD risk. It was concluded that both low PA and prolonged sitting augment CVD risk.[48]
- In a study that prospectively assessed the association of continuous inactivity and of changes in sitting time for 2 years with subsequent long-term all-cause mortality, it was found that compared with people who remained consistently sedentary, the HRs for mortality were 0.91 in those who were newly sedentary, 0.86 in formerly sedentary individuals, and 0.75 in those who remained consistently nonsedentary. Thus, subjects who reduced their sitting time over 2 years experienced an immediate reduction in mortality.[49]
- A meta-analysis of 17 eligible studies on PA in patients with DM revealed that the highest PA category in each study was associated with a lower RR (0.61) for all-cause mortality and CVD (0.71) than the lowest PA category. Although more PA was associated with larger reductions in future all-cause mortality and CVD, in patients with DM, any amount of habitual PA was better than inactivity.[50]
- In a special issue of *The Lancet* on PA, it was reported that the prevalence of physical inactivity (35%) worldwide is now greater than the prevalence of smoking (26%). On the basis of the HRs associated with these 2 behaviors (1.57 for smoking and 1.28 for inactivity), it was concluded that the PAR was greater for inactivity (9%) than for smoking (8.7%). Thus, inactivity was estimated to be responsible for 5.3 million deaths compared with 5.1 million deaths for smoking.[51]

Secondary Prevention

- In a retrospective cohort study that included 2086 patients (39% women, 56% white) who underwent clinical treadmill testing and had a first MI during follow-up (mean of 11 years), a higher baseline level of cardiorespiratory fitness was independently associated with a decreased risk of short-term mortality (28 days after a first MI).[52]

- PA improves inflammatory markers in people with existing stable CHD. After a 6-week training session, CRP levels declined by 23.7% ($P<0.001$), and plasma vascular cell adhesion molecule-1 levels declined by 10.23% ($P<0.05$); there was no difference in leukocyte count or levels of intercellular adhesion molecule-1.[53]
- In a randomized trial of patients with PAD, supervised treadmill exercise training and lower-extremity resistance training were each associated with significant improvements in functional performance and quality of life compared with a usual-care control group. Exercise training was additionally associated with improved brachial artery FMD, whereas resistance training was associated with better stair-climbing ability versus control.[54]
- On the basis of a meta-analysis of 34 RCTs, exercise-based cardiac rehabilitation after MI was associated with lower rates of reinfarction, cardiac mortality, and overall mortality.[55]
- The benefit of intense exercise training for cardiac rehabilitation in people with HF was tested in a trial of 27 patients with stable, medically treated HF. Intense activity (an aerobic interval-training program 3 times per week for 12 weeks) was associated with a significant 35% improvement in LV EF and decreases in pro-BNP (40%), LV end-diastolic volume (18%), and LV end-systolic volume (25%) compared with control and endurance-training groups.[56]
- Exercise training in patients with HF with preserved EF was associated with improved exercise capacity and favorable changes in diastolic function.[57]

Costs

- The economic consequences of physical inactivity are substantial. In a summary of WHO data sources, the economic costs of physical inactivity were estimated to account for 1.5% to 3.0% of total direct healthcare expenditures in developed countries such as the United States.[58]
- Interventions and community strategies to increase PA have been shown to be cost-effective in terms of reducing medical costs[59]:
  - —Nearly $3 in medical cost savings is realized for every $1 invested in building bike and walking trails.
  - —Incremental cost and incremental effectiveness ratios range from $14 000 to $69 000 per quality-adjusted life-year gained from interventions such as pedometer or walking programs compared with no intervention, especially in high-risk groups.

Table 4-1. Met 2008 Federal Aerobic and Strengthening PA Guidelines for Adults

Population Group	Prevalence, 2014 (Age ≥18 y), %
Both sexes	21.4
Males	25.4
Females	17.6
NH white only	23.6
NH black only	20.0
Hispanic or Latino	15.3
Asian only	17.0
American Indian/Alaska Native only	24.0

"Met 2008 federal PA guidelines for adults" is defined as engaging in ≥150 minutes of moderate or 75 minutes of vigorous aerobic leisure-time physical activity per week (or an equivalent combination) and engaging in leisure-time strengthening physical activity at least twice a week. Data are age adjusted for adults ≥18 years of age. NH indicates non-Hispanic; and PA, physical activity.

Source: National Health Interview Survey 2014 (National Center for Health Statistics).[11]

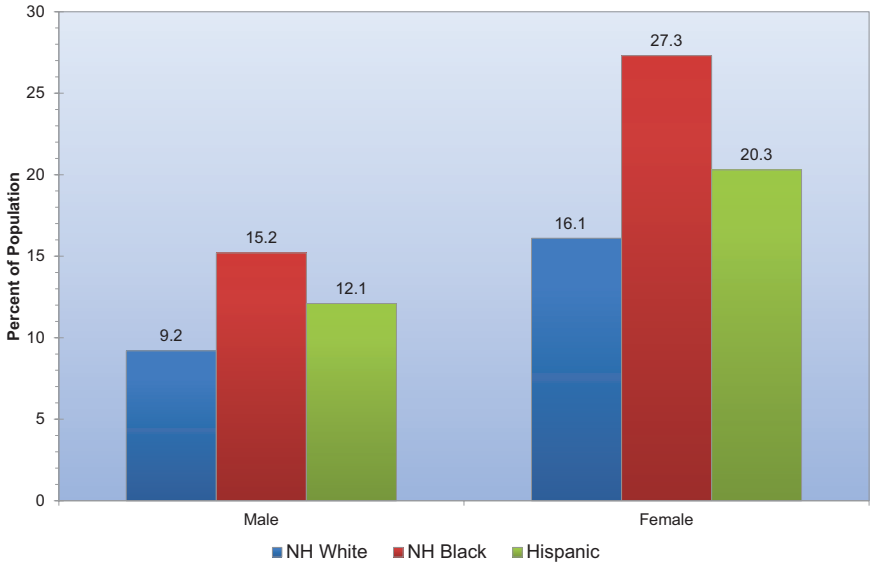

Chart 4-1. Prevalence of students in grades 9 to 12 who did not participate in ≥60 minutes of physical activity on any day in the past 7 days by race/ethnicity and sex (Youth Risk Behavior Surveillance: 2013). NH indicates non-Hispanic. Data derived from *MMWR Surveillance Summaries*.[8]

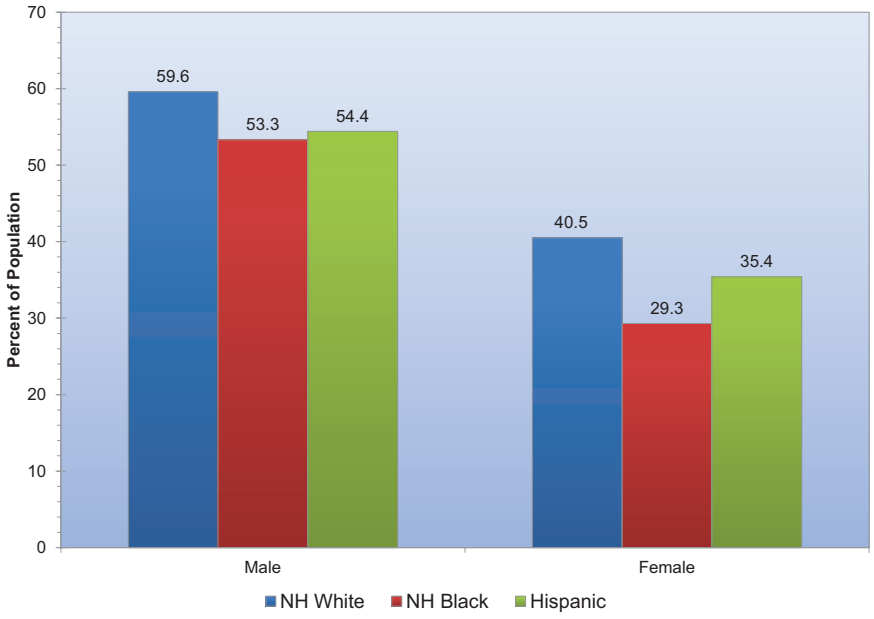

Chart 4-2. Prevalence of students in grades 9 to 12 who met currently recommended levels of physical activity during the past 7 days by race/ethnicity and sex (Youth Risk Behavior Surveillance: 2013). "Currently recommended levels" was defined as activity that increased their heart rate and made them breathe hard some of the time for a total of ≥60 minutes per day on 5 of the 7 days preceding the survey. NH indicates non-Hispanic. Data derived from *MMWR Surveillance Summaries*.[8]

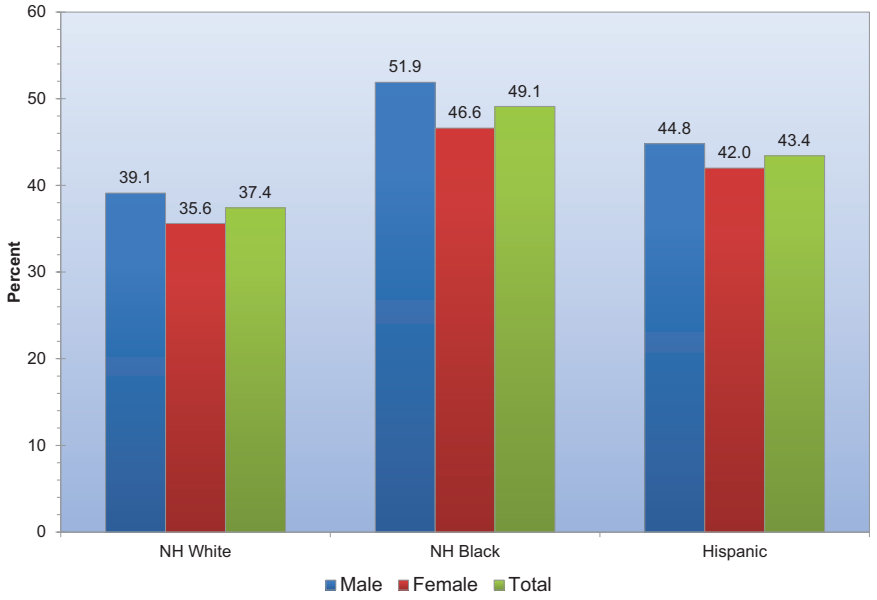

Chart 4-3. Percentage of students in grades 9 to 12 who used a computer for ≥3 hours on an average school day by race/ethnicity and sex (Youth Risk Behavior Surveillance: 2013). NH indicates non-Hispanic. Data derived from *MMWR Surveillance Summaries*.[8]

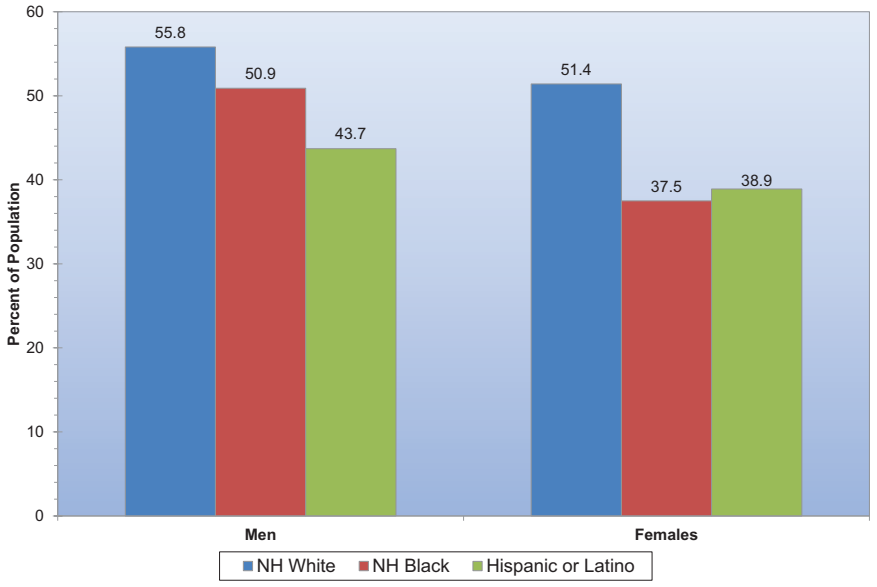

Chart 4-4. Prevalence of meeting the aerobic guidelines of the 2008 Federal Physical Activity Guidelines among adults ≥18 years of age by race/ethnicity and sex (National Health Interview Survey: 2014). Percentages are age adjusted. The aerobic guidelines of the 2008 Federal Physical Activity Guidelines recommend engaging in moderate leisure-time physical activity for ≥150 minutes per week or vigorous activity ≥75 minutes per week or an equivalent combination. NH indicates non-Hispanic. Source: National Health Interview Survey 2014 (National Center for Health Statistics).[11]

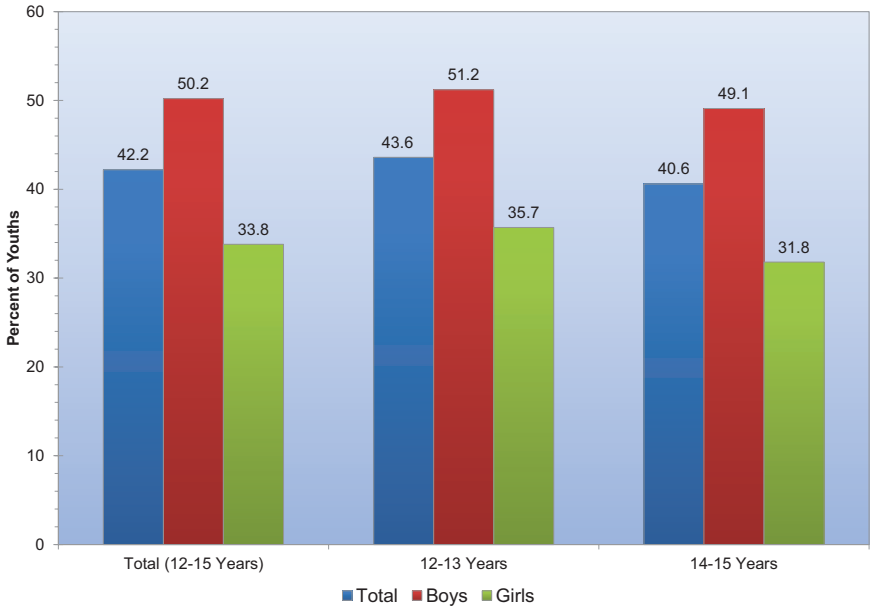

Chart 4-5. Prevalence of children 12 to 15 years of age who had adequate levels of cardiorespiratory fitness, by sex and age (National Health and Nutrition Examination Survey, National Youth Fitness Survey: 2012). Source: Gahche et al.[18]

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5. Nutrition

See Tables 5-1 through 5-3 and Charts 5-1 through 5-8.

This chapter of the Update highlights national dietary habits, focusing on key foods, nutrients, dietary patterns, and other dietary factors related to cardiometabolic health. It is intended to examine current intakes, trends and changes in intakes, and estimated effects on disease to support and further stimulate efforts to monitor and improve dietary habits in relation to cardiovascular health.

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Abbreviations Used in Chapter 5

AHA	American Heart Association
ALA	α-linoleic acid
ARIC	Atherosclerosis Risk in Communities Study
BMI	body mass index
BP	blood pressure
BRFSS	Behavioral Risk Factor Surveillance System
CHD	coronary heart disease
CI	confidence interval
CRP	C-reactive protein
CVD	cardiovascular disease
DALY	disability-adjusted life-year
DASH	Dietary Approaches to Stop Hypertension
DBP	diastolic blood pressure
DHA	docosahexaenoic acid
DM	diabetes mellitus
EPA	eicosapentaenoic acid
GFR	glomerular filtration rate
GISSI	Gruppo Italiano per lo Studio della Sopravvivenza nell'Infarto miocardico
HD	heart disease
HDL-C	high-density lipoprotein cholesterol
HF	heart failure
LDL-C	low-density lipoprotein cholesterol
MI	myocardial infarction
n-6-PUFA	ω-6-polyunsaturated fatty acid
NA	not available
NH	non-Hispanic
NHANES	National Health and Nutrition Examination Survey
OR	odds ratio
PA	physical activity
PREDIMED	Prevención con Dieta Mediterránea
RCT	randomized controlled trial
RR	relative risk
SBP	systolic blood pressure
SD	standard deviation
SSB	sugar-sweetened beverage
TC	total cholesterol
USDA	US Department of Agriculture
WHI	Women's Health Initiative

Prevalence and Trends in the AHA 2020 Healthy Diet Metrics

(See Table 5-1 and Charts 5-1 through 5-5.)

- The AHA's 2020 Impact Goals include a new priority of improving cardiovascular health.[1] The definition of cardiovascular health includes a healthy diet pattern, characterized by 5 primary and 3 secondary metrics (Table 5-1), that should be consumed within the context of a healthy dietary pattern that is appropriate in energy balance and consistent with a DASH-type eating plan.
- The AHA scoring system for ideal, intermediate, and poor diet patterns uses a binary-based scoring system, which awards 1 point for meeting the ideal target for each metric and 0 points otherwise.[2] For better consistency with other dietary pattern scores such as DASH, an alternative continuous scoring system has been developed to measure small improvements over time towards the AHA ideal target levels[3] (Table 5-1). The dietary targets remain the same, and progress toward each of these targets is assessed by use of a more granular range of 1 to 10 (rather than 0 to 1).
- On the basis of the alternative scoring system, between 2003 to 2004 and 2011 to 2012 in the United States, the mean AHA healthy diet score improved in both children and adults (Chart 5-1). The prevalence of an ideal healthy diet score (>80) increased from 0.2% to 0.6% in children (Chart 5-2) and from 0.7% to 1.5% in adults (Chart 5-3). The prevalence of an intermediate healthy diet score (40–79) increased from 30.6% to 44.7% in children and from 49.0% to 57.5% in adults.
- These improvements were largely attributable to increased whole grain consumption and decreased sugar-sweetened beverage consumption in both children and adults, as well as a small, nonsignificant trend in increased fruit and vegetable consumption (Charts 5-4 and 5-5). No major trends were evident in children or adults in progress toward the targets for consumption of fish or sodium.

Dietary Habits in the United States: Current Intakes

Foods and Nutrients: Adults

(See Table 5-2 and Charts 5-3, 5-5, and 5-6; NHANES 2011–2012.)

The dietary consumption by US adults of selected foods and nutrients related to cardiometabolic health is detailed in Table 5-2 according to sex and race or ethnic subgroups.

- Average consumption of whole grains was 1.1 servings per day by white men and women, 0.8 to 0.9 servings per day by black men and women, and 0.6 to 0.8 servings by Mexican American men and women. For each of these groups, fewer than 10% of adults meet guidelines of ≥3 servings per day.
- Average fruit consumption ranged from 1.2 to 1.6 servings per day in these sex and race or ethnic subgroups: ≈9% of whites, 7% of blacks, and 6% of Mexican Americans met guidelines of ≥2 cups per day. When 100% fruit juices were included, the number of servings increased, and the proportions of adults consuming ≥2 cups per day nearly doubled in whites, doubled in Mexican Americans, and tripled in blacks.

- Average nonstarchy vegetable consumption ranged from 1.7 to 2.7 servings per day. Across all race/ethnic subgroups, women were more likely than men to meet targets of consuming ≥2.5 cups per day.
- consumption was between 1.1 and 1.6 servings per day in whites and blacks and between 2.3 and 4.7 servings per day in Mexican Americans. Approximately 15% to 20% of whites and blacks, 25% of Mexican American women, and nearly 50% of Mexican American men met targets of consuming at least 1.5 cups per day.
- Average consumption of fish and shellfish was lowest among Mexican American women and white women (0.8 and 1.0 servings per week, respectively) and highest among black women and black and Mexican American men (1.9 and 1.7 servings per week, respectively). Generally only 15% to 25% of adults in each sex and race or ethnic subgroup consumed at least 2 servings per week.
- Average weekly consumption of nuts and seeds was ≈3.5 servings among whites and 2.5 servings among blacks and Mexican Americans. Approximately 1 in 4 whites, 1 in 6 blacks, and 1 in 8 Mexican Americans met guidelines of ≥4 servings per week.
- Average consumption of unprocessed red meats was higher in men than in women, up to 4.8 servings per week in Mexican American men.
- Average consumption of processed meats was lowest among Mexican American women (1.1 servings per week) and highest among black and white men (≈2.5 servings per week). Between 57% (white men) and 79% (Mexican American women) of adults consumed 2 or fewer servings per week.
- Average consumption of sugar-sweetened beverages ranged from 6.8 servings per week among white women to nearly 12 servings per week among Mexican American men. Women generally consumed less than men. From 33% (Mexican American men) to 65% (white women) of adults consumed no more than 36 oz per week.
- Average consumption of sweets and bakery desserts ranged from 3.9 servings per day (Mexican American men) to more than 7 servings per day (white women). Approximately 1 in 3 adults (1 in 2 Mexican American men) consumed no more than 2.5 servings per week.
- Average consumption of eicosapentaenoic acid and docosahexaenoic acid ranged from 58 to 117 mg/d in each sex and race or ethnic subgroup. Fewer than 8% of whites, 14% of blacks, and 11% of Mexican Americans consumed ≥250 mg/d.
- one third to one half of adults in each sex and race or ethnic subgroup consumed <10% of total calories from saturated fat, and approximately one half to two thirds consumed <300 mg of dietary cholesterol per day.
- Only ≈7% to 10% of whites, 4% to 5% of blacks, and 13% to 14% of Mexican Americans consumed ≥28 g of dietary fiber per day.
- Only ≈6% to 8% of adults in each age and race or ethnic subgroup consumed <2.3 g of sodium per day. Sodium is widespread in the US food supply, with diverse sources (Chart 5-4).
- Average daily energy intake among US adults was ≈2500 calories in men and 1800 calories in women.

Foods and Nutrients: Children and Teenagers

(See Table 5-3 and Charts 5-1, 5-2, and 5-4; NHANES 2011–2012.)

The dietary consumption by US children and teenagers of selected foods and nutrients related to cardiometabolic health is detailed in Table 5-3:

- Average whole grain consumption was low, <1 serving per day in all age and sex groups, with <5% of all children in different age and sex subgroups meeting guidelines of ≥3 servings per day.
- Average fruit consumption was low and decreased with age: 1.7 to 1.9 servings per day in younger boys and girls (5–9 years of age), 1.4 servings per day in adolescent boys and girls (10–14 years of age), and 0.9 to 1.3 servings per day in teenage boys and girls (15–19 years of age). The proportion meeting guidelines of ≥2 cups per day was also low and decreased with age: ≈8% to 14% in those 5 to 9 years of age, 3% to 8% in those 10 to 14 years of age, and 5% to 6% in those 15 to 19 years of age. When 100% fruit juices were included, the number of servings consumed increased by ≈50%, and proportions consuming ≥2 cups per day increased to nearly 25% of those 5 to 9 years of age, 20% of those 10 to 14 years, and 15% of those 15 to 19 years of age.
- Average nonstarchy vegetable consumption was low, ranging from 1.1 to 1.5 servings per day, with <1.5% of children in different age and sex subgroups meeting guidelines of ≥2.5 cups per day.
- Average legume consumption was between 0.7 and 1.3 servings per day in children in different age and sex subgroups. Approximately 9% to 17% of children in different age and sex subgroups met targets of consuming at least 1.5 cups per day.
- Average consumption of fish and shellfish was low, ranging between 0.3 and 1.0 servings per week in all age and sex groups. Among all ages, only 7% to 14% of youths consumed ≥2 servings per week.
- Average consumption of nuts, seeds, and beans ranged from 1.1 to 2.7 servings per week among different age and sex groups. The distribution of consumption tended to be skewed to the right, and generally fewer than 15% of children in different age and sex subgroups consumed ≥4 servings per week.
- Average consumption of unprocessed red meats was higher in boys than in girls and increased with age, up to 3.6 and 2.5 servings per week in 15- to 19-year-old boys and girls, respectively.
- Average consumption of processed meats ranged from 1.4 to 2.3 servings per week and was consistently higher than the average consumption of fish and shellfish in every age and sex subgroup. The distribution of consumption tended to be skewed to the right, and the majority of children consumed no more than 2 servings per week.
- Average consumption of sugar-sweetened beverages was higher in boys than in girls and increased substantially with age, from ≈6 to 8 servings (8 fl oz) per week in 5- to 9-year-olds to 12 to 14 servings per week in 15- to 19-year-olds (each energy adjusted to 2000 kcal/d). This was generally considerably higher than the average consumption of whole grains, fruits, vegetables, fish and shellfish, or nuts,

seeds, and beans. Only about half of children 5 to 9 years of age and one quarter of boys 15 to 19 years of age consumed <4.5 servings per week.
- Average consumption of sweets and bakery desserts was highest (≈7 to 8 servings per week) in 5- to 9-year-olds and 10- to 14-year-olds and modestly lower (≈5 to 6 servings per week) in 15- to 19-year-olds. A minority of children in all age and sex subgroups consumed no more than 2.5 servings per week.
- Average consumption of eicosapentaenoic acid and docosahexaenoic acid was low, ranging from 34 to 65 mg/d in boys and girls at all ages. Fewer than 7% of children and teenagers at any age consumed ≥250 mg/d.
- Average consumption of saturated fat was ≈11% of calories in boys and girls at all ages, and average consumption of dietary cholesterol ranged from ≈210 to 270 mg/d, increasing with age. Approximately 25% to 40% of youths consumed <10% energy from saturated fat, and ≈70% to 80% consumed <300 mg of dietary cholesterol per day.
- Average consumption of dietary fiber ranged from ≈14 to 16 g/d. Less than 3% of children in all age and sex subgroups consumed ≥28 g/d.
- Average consumption of sodium ranged from 3.1 to 3.5 g/d. Only between 2% and 11% of children in different age and sex subgroups consumed <2.3 g/d.
- In children and teenagers, average daily caloric intake is higher in boys than in girls and increases with age in boys.

Dietary Patterns

In addition to individual foods and nutrients, overall dietary patterns can be very useful to assess diet quality.[4] Different dietary patterns have been defined, such as Mediterranean, DASH-type, Healthy Eating Index–2010, Alternate Healthy Eating Index, Western, prudent, and vegetarian patterns. The original DASH diet was low fat; a higher-monounsaturated-fat DASH-type diet is even more healthful and similar to a traditional Mediterranean dietary pattern.[5]

- The Healthy Eating Index–2010, which reflects compliance with the 2010 US Dietary Guidelines, exhibits a wide distribution among the US population, with a 5th percentile score of 31.7 and a 95th percentile score of 70.4 in 2003 to 2004 (theoretical maximum=100).[6] Average diet quality is worse in men (score=49.8) than in women (52.7), in younger adults (45.4) than in older adults (56.1), and in smokers (45.7) than in nonsmokers (53.3).
- Between 1999 and 2010, the average Alternate Healthy Eating Index–2010 score of US adults improved from 39.9 to 46.8.[7] This was related to reduced intake of *trans* fat (accounting for more than half of the improvement), sugar-sweetened beverages, and fruit juice and increased intake of whole fruit, whole grains, polyunsaturated fatty acids, and nuts and legumes. Adults with greater family income and education had higher scores, and the gap between low and high socioeconomic status widened over time, from 3.9 points in 1999 to 2000 to 7.8 points in 2009 to 2010.
- Worldwide, 2 separate, relatively uncorrelated dietary patterns can be characterized: 1 by greater intakes of healthful foods (eg, fruits, vegetables, nuts, fish) and 1 by lower intakes of unhealthful foods (eg, processed meats, sugar-sweetened beverages).[8] In 2010, compared with low-income nations, high-income nations had better diet patterns based on healthful foods but substantially worse diet patterns based on unhealthful foods. Between 1990 and 2010, both types of dietary patterns improved in high-income Western countries but worsened or did not improve in low-income countries in Africa and Asia. Middle-income countries showed the largest improvements in dietary patterns based on healthful foods but the largest deteriorations in dietary patterns based on unhealthful foods. Overall, global consumption of healthy foods improved but was outpaced by increased intake of unhealthy foods in most world regions.

Dietary Supplements

Use of dietary supplements is common in the United States among both adults and children:

- Approximately half of US adults in 2007 to 2010 used ≥1 dietary supplement, with the most common supplement being multivitamin-multimineral products (32% of men and women reporting use).[9] It has been shown that most supplements are taken daily and for ≥2 years.[10]). Supplement use is associated with older age, higher education, greater PA, moderate alcohol consumption, lower BMI, abstinence from smoking, having health insurance, and white race.[9,10] Previous research also suggests that supplement users have higher intakes of most vitamins and minerals from their food choices alone than nonusers.[11,12] The primary reasons US adults in 2007 to 2010 reported for using dietary supplements were to "improve overall health" (45%) and to "maintain health" (33%).[9]
- One third (32%) of US children (birth to 18 years of age) used dietary supplements in 1999 to 2002, with the highest use (48.5%) occurring among 4- to 8-year-olds. The most common supplements were multivitamins and multiminerals (58% of supplement users). The primary nutrients supplemented (either by multivitamins or individual vitamins) included vitamin C (29% of US children), vitamin A (26%), vitamin D (26%), calcium (21%), and iron (19%). Supplement use was associated with higher family income, a smoke-free home environment, lower child BMI, and less screen time (television, video games, or computers).[13]
- In a 2005 to 2006 telephone survey of US adults, 41.3% were making or had made in the past a serious weight-loss attempt. Of these, one third (33.9%) had used a dietary supplement for weight loss, with such use being more common in women (44.9%) than in men (19.8%) and in blacks (48.7%) or Hispanics (41.6%) than in whites (31.2%); in those with high school education or less (38.4%) than in those with some college or more (31.1%); and in those with household income <$40 000 per year (41.8%) than in those with higher incomes (30.3%).[14]
- Multiple trials of most dietary supplements, including folate, vitamin C, and vitamin E, have generally shown no significant benefits for CVD risk, and even potential for harm.[15] For example, a multicenter randomized trial in patients with diabetic nephropathy found that B vitamin supplementation (folic acid 2.5 mg/d, vitamin B_6 25 mg/d, and vitamin B_{12} 1 mg/d) decreased GFR and increased risk of MI and stroke compared with placebo.[16]
- Fish oil supplements at doses of 1 to 2 g/d have shown CVD benefits in 2 large randomized, open-label trials and 1 large

randomized, placebo-controlled trial (GISSI-Prevenzione, Japan Eicosapentaenoic Acid Lipid Intervention Study, and GISSI-HF),[17–19] but several other trials of fish oil have not shown significant effects on CVD risk.[20] A meta-analysis of all RCTs demonstrated a significant reduction for cardiac mortality but no statistically significant effects on other CVD end points.[21]

Trends in Energy Balance and Adiposity

(See Chapter 6 on Overweight and Obesity.)

- The average US adult gains ≈1 lb per year. Energy balance, or consumption of total calories appropriate for needs, is determined by the balance of average calories consumed versus expended. This balance depends on multiple factors, including calories consumed, PA, body size, age, sex, and underlying basal metabolic rate. Thus, one individual may consume relatively high calories but have negative energy balance (as a result of even greater calories expended), whereas another individual may consume relatively few calories but have positive energy balance (because of low calories expended). Given such variation, the most practical and reasonable method to assess energy balance in populations is to assess changes in weight over time. Growing evidence indicates that calorie for calorie, certain foods may be more highly obesogenic; others, modestly obesogenic; others, relatively neutral; and still others, actually protective against weight gain when their consumption is increased. These varying effects appear to relate to divergent influences on complex physiological pathways of long-term weight regulation, including related to hunger, satiety, brain reward, hepatic de novo lipogenesis, adipocyte function, visceral adiposity, interactions with the gut inflammasome and microbiome, and energy expenditure. This evidence is detailed below.
- The US epidemic of overweight and obesity is a relatively recent phenomenon, with dramatic increases in both children and adults after 1980 compared with prior decades. These trends are evidenced across broad cross sections of sex, race/ethnicity, geographic residence, and socioeconomic status. In more recent years, rates of obesity and overweight among both US adults and children have begun to level off.[22] Examination of trends in diet, activity, and other factors from 1980 to the present is important to elucidate the drivers of this remarkably recent epidemic.
- Until 1980, total energy intake remained relatively constant.[23,24] However, data from NHANES indicate that between 1971 and 2004, average total energy intake among US adults increased by 22% in women (from 1542 to 1886 kcal/d) and by 10% in men (from 2450 to 2693 kcal/d).[25] These increases are supported by data from 2 older surveys, the Nationwide Food Consumption Survey (1977–1978) and the Continuing Surveys of Food Intake (1989–1998).[26] More recent data show that energy intake appears to have relatively stabilized among US adults between 1999 and 2008.[27]
- Another analysis of national data estimated that increases in energy intake between 1980 and 1997 were primarily attributable to increases in dietary carbohydrates.[28] Specifically, nearly 80% of the increase in total energy came from carbohydrates, 12% from protein, and only 8% from fat. These increases in calories were primarily attributable to greater refined carbohydrate intake, particularly of starches, refined grains, and sugars (see Trends in Specific Dietary Habits).
- Other specific changes related to increased caloric intake in the United States since 1980 include larger portion sizes, greater food quantity and calories per meal, and increased consumption of sugar-sweetened beverages, snacks, and commercially prepared (especially fast-food) meals.[26,29–34] In more recent years, intakes of sugar-sweetened beverages have been decreasing nationally.[7,35]
- Between 1977 and 1996, the average portion sizes for many foods increased at fast-food outlets, other restaurants, and home. On the basis of one study, these included a 33% increase in the average portion of Mexican food (from 408 to 541 calories), a 34% increase in the average portion of cheeseburgers (from 397 to 533 calories), a 36% increase in the average portion of french fries (from 188 to 256 calories), and a 70% increase in the average portion of salty snacks such as crackers, potato chips, pretzels, puffed rice cakes, and popcorn (from 132 to 225 calories).[26]
- In one analysis, among US children 2 to 7 years of age, an estimated energy imbalance of only 110 to 165 kcal/d (the equivalent of one 12- to 16-oz bottle of soda/cola) was sufficient to account for the excess weight gain between 1988 to 1994 and 1999 to 2002.[36]
- In a quantitative analysis using various US surveys between 1977 and 2010, the relations of national changes in energy density, portion sizes, and number of daily eating/drinking occasions to changes in total energy intake were assessed.[23,24] Changes in energy density were not consistently linked to energy intake over time, whereas increases in both portion size and number of eating occasions were linked to greater energy intake.
- Among US children 2 to 18 years of age, increases in energy intake between 1977 and 2006 (179 kcal/d) were entirely attributable to substantial increases in energy eaten away from home (255 kcal/d).[37] The percentage of energy eaten away from home increased from 23.4% to 33.9% during this time, with a shift toward energy from fast food as the largest contributor to foods away from home for all age groups.
- A county-level investigation based on BRFSS and NHANES data found that prevalence of sufficient PA in the United States actually increased from 2001 to 2009 but that this was matched by increases in obesity in almost all counties during the same time period, with low correlation between level of PA and obesity in US counties.[38]

Determinants: Nutrients

- For short-term (up to 1–2 years) weight loss among overweight and obese individuals, the macronutrient composition of the diet has much less influence than compliance with the selected diet.[4]
- In ad libitum (not energy restricted) diets, a low-carbohydrate (high fat) diet demonstrated better weight loss and reduced fat mass than a low-fat (high carbohydrate) diet at 1 year.[39]
- In ad libitum (not energy restricted) diets, intake of dietary sugars is positively linked to weight gain.[40] However,

isoenergetic exchange of dietary sugars with other carbohydrates had no relationship with body weight,[40] which suggests that all refined carbohydrates (complex starches and simple sugars) may be similarly obesogenic.
- In pooled analyses across 3 prospective cohort studies of US men and women, increased glycemic index and glycemic load were independently associated with greater weight gain over time.[41]
- Across types of foods, energy density (total calories per gram of food) is not consistently linked with weight gain or obesity. For example, nuts have relatively high energy density and are inversely linked to weight gain, and cheese has high energy density and appears relatively neutral, whereas sugar-sweetened beverages have low energy density and increase obesity.[41] National changes in energy density over time are not consistently linked to changes in energy intake.[23]

Determinants: Foods

- In analyses of >120 000 US men and women in 3 separate US cohorts followed up for up to 20 years, changes in intakes of different foods and beverages were linked to long-term weight gain in different ways.[41,42] Foods and beverages most positively linked to weight gain included high-glycemic carbohydrates such as potatoes, white bread, white rice, low-fiber breakfast cereals, sweets/desserts, and sugar-sweetened beverages, as well as red and processed meats. In contrast, increased consumption of several other foods, including nuts, whole grains, fruits, vegetables, legumes, fish, and yogurt, was linked to relative weight loss over time. These findings suggest that attention to food-based dietary quality, not simply counting total calories, is crucial for long-term weight homeostasis.
- In both adults and children, intake of sugar-sweetened beverages has been linked to weight gain and obesity.[43] Randomized trials in children demonstrate reductions in obesity when sugar-sweetened beverages are replaced with noncaloric beverages.[43]

Determinants: Mechanisms

- Diet quality influences activation of brain reward centers, such as the nucleus accumbens. Isocaloric meals richer in rapidly digestible carbohydrate increased hunger and stimulated brain regions associated with reward and craving compared with isocaloric meals that had identical macronutrient content, palatability, and sweetness but were lower in rapidly digestible carbohydrate.[44]
- Dietary factors that stimulate hepatic de novo lipogenesis, such as rapidly digestible grains, starches, and sugars, as well as *trans* fat, appear more strongly related to weight gain.[41,42,45]
- In animal experiments, probiotics in yogurt alter gut immune responses and protect against obesity and nonalcoholic fatty acid liver disease.[46–48]
- Diet quality may also influence energy expenditure. After intentional weight loss, isocaloric diets higher in fat and lower in rapidly digestible carbohydrates produced significantly smaller declines in total energy expenditure than low-fat, high-carbohydrate diets, with a mean difference of >300 kcal/d.[49]
- Other possible nutritional determinants of positive energy balance (more calories consumed than expended), as determined by adiposity or weight gain, include larger portion sizes, skipping breakfast, consumption of fast food, and eating foods prepared outside the home, although the evidence for long-term relevance of these factors has been inconsistent.[50–53]

Determinants: Other Factors

- Sedentary activity has been hypothesized to be linked to weight gain because of changes in metabolism; however, the strongest and most consistent associations have been seen for television watching as opposed to all sedentary activities. In 2 RCTs, the benefits of reduced television watching for obesity were mediated by improvements in diet rather than increases in PA, which may be related to greater snacking/eating in front of the television and the influence of television advertising on poor food choices overall.[42,54–58]
- PA influences adiposity, as covered in Chapter 4 of this Update.
- Lower average sleep duration is consistently linked to greater adiposity in both children and adults, and short-term trials demonstrate effects of insufficient sleep on hunger, food choices, and leptin/ghrelin concentrations.[59]
- Societal and environmental factors independently associated with diet quality, adiposity, or weight gain include education, income, race/ethnicity, and (at least cross-sectionally) neighborhood availability of supermarkets.[15,60,61]
- Other local food-environment characteristics, such as availability of grocery stores (ie, smaller stores than supermarkets), convenience stores, and fast-food restaurants, are not consistently associated with diet quality or adiposity.[62]

Trends in Specific Dietary Habits

Several changes in foods and nutrients have occurred over time. Selected changes are highlighted below.

Trends in Macronutrients

- Starting in 1977 and continuing until the most recent dietary guidelines revision in 2010, a major focus of US dietary guidelines was reduction of dietary fats.[63] During this time, average total fat consumption declined as a percent of calories from 36.9% to 33.4% in men and from 36.1% to 33.8% in women.[25] After this significant decline, total fat consumption remained relatively stable among US adults from 1999 to 2008.[27]
- Dietary guidelines during this time also emphasized carbohydrates, including many refined carbohydrates, as the foundation of one's dietary pattern.[63,64] Consistent with this message, from 1971 to 2004, total carbohydrate intake increased from 42.4% to 48.2% of calories in men and from 45.4% to 50.6% of calories in women.[25] Evaluated as absolute intakes, the increase in total calories consumed during this period was attributable primarily to the greater consumption of carbohydrates, both as foods (starches and grains) and as beverages.[65,66] In more recent years, these trends have stabilized, with relatively stable intakes to slight declines in carbohydrate intake (expressed as percentage of energy) among US children and adults from 1999 to 2010, with corresponding slight increases in protein intake.[67]

Trends in Sugar-Sweetened Beverages

(See Charts 5-4, 5-5, and 5-7.)

- Between 1965 and 2002, the average percentage of total calories consumed from beverages in the United States increased from 11.8% to 21.0% of energy, which represents an overall absolute increase of 222 kcal/d per person.[33] This increase was largely caused by increased consumption of sugar-sweetened beverages and alcohol: Average consumption of fruit juices went from 20 to 39 kcal/d; of milk, from 125 to 94 kcal/d; of alcohol, from 26 to 99 kcal/d; of sweetened fruit drinks, from 13 to 38 kcal/d; and of soda/cola, from 35 to 143 kcal/d.[23]
- In addition to increased overall consumption, the average portion size of a single sugar-sweetened beverage increased by >50% between 1977 and 1996, from 13.1 to 19.9 fl oz.[26]
- Among children and teenagers (2–19 years of age), the largest increases in consumption of sugar-sweetened beverages between 1988 to 1994 and 1999 to 2004 were seen among black and Mexican American youths compared with white youths.[34]
- In contrast, between 1999 and 2010, sugar-sweetened beverage intake decreased among both youths and adults in the United States, consistent with increased attention to their importance as a cause of obesity. In 2009 to 2010, youths and adults consumed a daily average of 155 and 151 kcal from sugar-sweetened beverages, respectively, a decrease from 1999 to 2000 of 68 and 45 kcal/d, respectively.[68] This reduction parallels the plateau of the obesity epidemic in US youths.[22]
- Between 2003 to 2004 and 2011 to 2012, there was significant progress toward success for both US adults and children in achieving the AHA 2020 dietary target of no more than 36 fl oz of sugar-sweetened beverages per week (Charts 5-4 and 5-5).
- Globally, between 1999 and 2010, sugar-sweetened beverage intake increased in several countries.[69] Among adults, mean global intake was highest in men aged 20 to 39 years, at 1.04 8-oz servings per day. In comparison, globally, women >60 years of age had the lowest mean consumption at 0.34 servings per day. Sugar-sweetened beverage consumption was highest in the Caribbean, with adults consuming on average 2 servings per day, and lowest in East Asia, at 0.20 servings per day. Adults in the United States had the 26th-highest consumption of 187 countries.

Trends in Selected Foods

(See Charts 5-4 and 5-5.)

- Between 1994 and 2005, the average consumption of fruits and vegetables declined slightly, from a total of 3.4 to 3.2 servings per day. The proportions of men and women consuming combined fruits and vegetables ≥5 times per day were low (≈20% and 29%, respectively) and did not change during this period.[70]
- Between 2003 to 2004 and 2011 to 2012, there was no major change in the success of US adults or children in achieving the AHA 2020 dietary targets of 4.5 cups of total fruits and vegetables per day or 2 servings of fish per week. During this same period, there was significant progress toward success of both US adults and children in achieving the AHA 2020 dietary target of at least three 1-oz servings of whole grains per day (Charts 5-4 and 5-5).

Trends in Sodium

(See Charts 5-4 through 5-6.)

- Although inconsistent methodology over time limits the ability to make strong conclusions, the current available data suggest that US sodium intake has remained relatively stable between 1957 and 2003.[71]
- Worldwide in 2010, mean sodium intake among adults was 3950 mg/d, which corresponds to salt intake of ≈10 g/d.[72] Across world regions, mean sodium intakes were highest in Central Asia (5510 mg/d) and lowest in Eastern sub-Saharan Africa (2180 mg/d). Across countries, the lowest observed mean national intakes were ≈1500 mg/d. Between 1990 and 2010, global mean sodium intake appeared to remain relatively stable, although data on trends in many world regions were suboptimal.

Morbidity and Mortality

Effects on Cardiovascular Risk Factors and Type 2 DM

Dietary habits affect multiple cardiovascular risk factors, including both established risk factors (SBP, DBP, LDL-C levels, HDL-C levels, glucose levels, and obesity/weight gain) and novel risk factors (eg, inflammation, cardiac arrhythmias, endothelial cell function, triglyceride levels, lipoprotein[a] levels, and heart rate):

- Sodium linearly raises BP in a dose-dependent fashion, with stronger effects among older people, hypertensive individuals, and blacks,[73] and induces additional BP-independent damage to renal and vascular tissues.[74,75]
- Compared with a usual Western diet, a DASH-type dietary pattern with low sodium reduced SBP by 7.1 mm Hg in adults without hypertension and by 11.5 mm Hg in adults with hypertension.[76]
- Compared with the low-fat DASH diet, DASH-type diets that increased consumption of either protein or unsaturated fat had similar or greater beneficial effects on CVD risk factors. Compared with a baseline usual diet, each of the DASH-type diets, which included various percentages (27%–37%) of total fat and focused on whole foods such as fruits, vegetables, whole grains, and fish, as well as potassium and other minerals and low sodium, reduced SBP by 8 to 10 mm Hg, DBP by 4 to 5 mm Hg, and LDL-C by 12 to 14 mg/dL. The diets that had higher levels of protein and unsaturated fat also lowered triglyceride levels by 16 and 9 mg/dL, respectively.[77] The DASH-type diet higher in unsaturated fat also improved glucose-insulin homeostasis compared with the low-fat/high-carbohydrate DASH diet.[78]
- In a meta-analysis of 60 randomized controlled feeding trials, consumption of 1% of calories from saturated fat in place of carbohydrate raised LDL-C concentrations but also raised HDL-C and lowered triglycerides, with no significant effects on apolipoprotein B concentrations.[79]
- In a meta-analysis of RCTs, consumption of 1% of calories from *trans* fat in place of saturated fat, monounsaturated fat, or polyunsaturated fat, respectively, increased the ratio of TC to HDL-C by 0.031, 0.054, and 0.67; increased

apolipoprotein B levels by 3, 10, and 11 mg/L; decreased apolipoprotein A-1 levels by 7, 5, and 3 mg/L; and increased lipoprotein(a) levels by 3.8, 1.4, and 1.1 mg/L.[80]

- In meta-analyses of RCTs, consumption of eicosapentaenoic acid and docosahexaenoic acid for 212 weeks lowered SBP by 2.1 mm Hg[81] and lowered resting heart rate by 2.5 beats per minute.[82]
- In a pooled analysis of 25 randomized trials totaling 583 men and women both with and without hypercholesterolemia, nut consumption significantly improved blood lipid levels.[70,83] For a mean consumption of 67 g of nuts per day, TC was reduced by 10.9 mg/dL (5.1%), LDL-C by 10.2 mg/dL (7.4%), and the ratio of TC to HDL-C by 0.24 (5.6% change; $P<0.001$ for each). Triglyceride levels were also reduced by 20.6 mg/dL (10.2%) in subjects with high triglycerides (2150 mg/dL). Different types of nuts had similar effects.[83]
- A review of cross-sectional and prospective cohort studies suggests that higher intake of sugar-sweetened beverages is associated with greater visceral fat and higher risk of type 2 DM.[84]
- In an RCT, compared with a low-fat diet, 2 Mediterranean dietary patterns that included either virgin olive oil or mixed nuts lowered SBP by 5.9 and 7.1 mm Hg, plasma glucose by 7.0 and 5.4 mg/dL, fasting insulin by 16.7 and 20.4 pmol/L, the homeostasis model assessment index by 0.9 and 1.1, and the ratio of TC to HDL-C by 0.38 and 0.26 and raised HDL-C by 2.9 and 1.6 mg/dL, respectively. The Mediterranean dietary patterns also lowered levels of CRP, interleukin-6, intercellular adhesion molecule-1, and vascular cell adhesion molecule-1.[85]
- Among 24 prospective cohort studies, greater consumption of refined carbohydrates and sugars, as measured by higher glycemic load, was positively associated with risk of type 2 DM: For each 100-g increment in glycemic load, 45% higher risk was seen (95% CI, 1.31–1.61; $P<0.001$; n=24 studies, 7.5 million person-years of follow-up).[86]
- In one meta-analysis of observational studies and trials, greater consumption of nuts was linked to lower incidence of type 2 DM (RR per 4 weekly 1-oz servings, 0.87; 95% CI, 0.81–0.94).[87]

Effects on Cardiovascular Outcomes

Because dietary habits affect a broad range of established and novel risk factors, estimation of the impact of nutritional factors on cardiovascular health by considering only a limited number of pathways (eg, only effects on lipids, BP, and obesity) will systematically underestimate or even misconstrue the actual total impact on cardiovascular health. RCTs and prospective observational studies have been used to quantify the total effects of dietary habits on clinical outcomes.

Fats and Carbohydrates

- In the WHI randomized clinical trial (n=48 835), reduction of total fat consumption from 37.8% energy (baseline) to 24.3% energy (at 1 year) and 28.8% energy (at 6 years) had no effect on incidence of CHD (RR, 0.98; 95% CI, 0.88–1.09), stroke (RR, 1.02; 95% CI, 0.90–1.15), or total CVD (RR, 0.98; 95% CI, 0.92–1.05) over a mean of 8.1 years.[88] This was consistent with null results of 4 prior randomized clinical trials and multiple large prospective cohort studies that indicated little effect of total fat consumption on CVD risk.[89]
- In 3 separate meta-analyses of prospective cohort studies, the largest of which included 21 studies with up to 2 decades of follow-up, saturated fat consumption overall had no significant association with incidence of CHD, stroke, or total CVD.[90–92] In comparison, in a pooled individual-level analysis of 11 prospective cohort studies, the specific exchange of polyunsaturated fat consumption in place of saturated fat was associated with lower CHD risk, with 13% lower risk for each 5% energy exchange (RR, 0.87; 95% CI, 0.70–0.97).[93] These findings are consistent with a meta-analysis of RCTs in which increased polyunsaturated fat consumption in place of saturated fat reduced CHD events, with 10% lower risk for each 5% energy exchange (RR, 0.90; 95% CI, 0.83–0.97).[94]
- In a pooled analysis of individual-level data from 11 prospective cohort studies in the United States, Europe, and Israel that included 344 696 participants, each 5% higher energy consumption of carbohydrate in place of saturated fat was associated with a 7% higher risk of CHD (RR, 1.07; 95% CI, 1.01–1.14).[93] Each 5% higher energy consumption of monounsaturated fat in place of saturated fat was not significantly associated with CHD risk.[93] A more recent meta-analysis of prospective cohort studies found that increased intake of polyunsaturated fats was associated with lower risk of CHD, whether replacing saturated fat or carbohydrate.[95]
- Together these findings suggest that reducing saturated fat without specifying the replacement may have minimal effects on CHD risk, whereas increasing polyunsaturated fats from vegetable oils will reduce CHD, whether replacing saturated fat or carbohydrate.[5]
- In a meta-analysis of prospective cohort studies, each 2% of calories from *trans* fat was associated with a 23% higher risk of CHD (RR, 1.23; 95% CI, 1.11–1.37).[96]
- In meta-analyses of prospective cohort studies, greater consumption of refined complex carbohydrates, starches, and sugars, as assessed by glycemic index or load, was associated with significantly higher risk of CHD and DM. When the highest category was compared with the lowest category, risk of CHD was 36% greater (glycemic load: RR, 1.36; 95% CI, 1.13–1.63), and risk of DM was 40% greater (glycemic index: RR, 1.40; 95% CI, 1.23–1.59).[97,98]

Foods and Beverages

- In meta-analyses of prospective cohort studies, each daily serving of fruits or vegetables was associated with a 4% lower risk of CHD (RR, 0.96; 95% CI, 0.93–0.99) and a 5% lower risk of stroke (RR, 0.95; 95% CI, 0.92–0.97).[99,100]
- In a meta-analysis of prospective cohort studies, greater whole grain intake (2.5 compared with 0.2 servings per day) was associated with a 21% lower risk of CVD events (RR, 0.79; 95% CI, 0.73–0.85), with similar estimates in men and women and for various outcomes (CHD, stroke, and fatal CVD). In contrast, refined grain intake was not associated with lower risk of CVD (RR, 1.07; 95% CI, 0.94–1.22).[101]
- In a meta-analysis of 16 prospective cohort studies that included 326 572 generally healthy individuals in Europe, the United States, China, and Japan, fish consumption was

associated with significantly lower risk of CHD mortality.[102] Compared with no consumption, an estimated 250 mg of long-chain omega-3 fatty acids per day was associated with 35% lower risk of CHD death ($P<0.001$).

- In a meta-analysis of prospective cohort and case-control studies from multiple countries, consumption of unprocessed red meat was not significantly associated with incidence of CHD. In contrast, each 50-g serving per day of processed meats (eg, sausage, bacon, hot dogs, deli meats) was associated with a higher incidence of CHD (RR, 1.42; 95% CI, 1.07–1.89).[103]
- In a meta-analysis of prospective cohort studies that included 442 101 participants and 28 228 DM cases, unprocessed red meat consumption was associated with a higher risk of DM (RR, 1.19; 95% CI, 1.04–1.37, per 100 g/d). On a per g/d basis, risk of DM was nearly 7-fold higher for processed meat consumption (RR, 1.51; 95% CI, 1.25–1.83, per 50 g/d).[104]
- In a meta-analysis of 6 prospective observational studies, nut consumption was associated with lower incidence of fatal CHD (RR per 4 weekly 1-oz servings, 0.76; 95% CI, 0.69–0.84) and nonfatal CHD (RR, 0.78; 95% CI, 0.67–0.92).[87] Nut consumption was not significantly associated with stroke risk based on 4 studies.[87]
- In a meta-analysis of 6 prospective observational studies, consumption of legumes (beans) was associated with lower incidence of CHD (RR per 4 weekly 100-g servings, 0.86; 95% CI, 0.78–0.94).[87]
- Higher consumption of dairy or milk products is associated with lower incidence of DM and trends toward lower risk of stroke.[83,97,98] The inverse associations with DM appear strongest for both yogurt and cheese.[105]
- Dairy consumption is not significantly associated with higher or lower risk of CHD.[91,106]
- Among 88 520 generally healthy women in the Nurses' Health Study who were 34 to 59 years of age in 1980 and were followed up from 1980 to 2004, regular consumption of sugar-sweetened beverages was independently associated with higher incidence of CHD, with 23% and 35% higher risk with 1 and ≥2 servings per day, respectively, compared with <1 per month.[107] Among the 15 745 participants in the ARIC study, the OR for developing CHD was 2.59 for participants who had a serum uric acid level >9.0 mg/dL and who drank >1 sugar-sweetened soda per day.[108]

Potassium and Sodium

- Major dietary sources of potassium include vegetables, fruits, whole grains, legumes, nuts, and dairy. In randomized trials, potassium lowers BP, with stronger effects among hypertensive people and when dietary sodium intake is high.[109] BP lowering is related to both increased urinary potassium excretion and a lower urine sodium-to-potassium ratio. Consistent with these benefits, potassium-rich diets are associated with lower risk of CVD, especially stroke.[110]
- Nearly all observational studies demonstrate a positive association between higher estimated sodium intakes (eg, >4000 mg/d) and CVD events, in particular stroke.[111,112] Some studies have also observed higher CVD risk at estimated low intakes (eg, <3000 g/d), which suggests a potential J-shaped relationship with risk.[113–115] Unique limitations in estimating sodium intake in observational studies, whether by urine collection or diet questionnaires, could explain the J shape seen in certain studies.[116]
- During extended surveillance in a large sodium study that excluded sick people at baseline and collected multiple 24-hour urine samples per subject, individuals with sodium intake <2300 mg/d experienced 32% lower CVD risk than those who consumed 3600 to 4800 mg/d, with evidence for linearly decreasing risk.[117]
- In ecological studies, the lowest mean intake level associated with both lower systolic BP and lower age-BP slope was 614 mg/d.[118]
- In well-controlled, randomized feeding trials, the lowest tested intake for which BP reductions were clearly documented was 1500 mg/d.[76]
- In meta-analyses of prospective observational studies, the lowest mean intakes associated with lower risk of CVD events ranged from 1787 to 2391 mg/d.[111,112]
- In a post hoc analysis of the Trials of Hypertension Prevention, participants randomized to low-sodium interventions had a 25% lower risk of CVD (RR, 0.75; 95% CI, 0.57–0.99) after 10 to 15 years of follow-up after the original trials.[119]

Dietary Patterns

- The 2015 US Dietary Guidelines Advisory Committee recently summarized the evidence for benefits of healthful diet patterns on a range of cardiometabolic and other disease outcomes.[4] They concluded that a healthy dietary pattern is higher in vegetables, fruits, whole grains, low-fat or nonfat dairy, seafood, legumes, and nuts; moderate in alcohol (among adults); lower in red and processed meat; and low in sugar-sweetened foods and drinks and refined grains.
- In a cohort of 380 296 US men and women, greater versus lower adherence to a Mediterranean dietary pattern, characterized by higher intakes of vegetables, legumes, nuts, fruits, whole grains, fish, and unsaturated fat and lower intakes of red and processed meat, was associated with a 22% lower cardiovascular mortality (RR, 0.78; 95% CI, 0.69–0.87).[120] Similar findings have been seen for the Mediterranean dietary pattern and risk of incident CHD and stroke[121] and for the DASH-type dietary pattern.[122]
- In a cohort of 72 113 US female nurses, a dietary pattern characterized by higher intakes of vegetables, fruits, legumes, fish, poultry, and whole grains was associated with a 28% lower cardiovascular mortality (RR, 0.72; 95% CI, 0.60–0.87), whereas a dietary pattern characterized by higher intakes of processed meat, red meat, refined grains, french fries, and sweets/desserts was associated with a 22% higher cardiovascular mortality (RR, 1.22; 95% CI, 1.01–1.48).[123] Similar findings have been seen in other cohorts and for other outcomes, including development of DM and metabolic syndrome.[124–130]
- The observational findings for benefits of a healthy food–based dietary pattern have been confirmed in 2 randomized clinical trials, including a small secondary prevention trial in France among patients with recent MI[131] and a large primary prevention trial in Spain among patients with CVD risk factors.[132] The latter trial, PREDIMED, demonstrated a 30% reduction in the risk of stroke, MI, and death

attributable to cardiovascular causes in those patients randomized to Mediterranean-style diets rich in extra-virgin olive oil or mixed nuts.

Impact on US Mortality

- One report used consistent and comparable risk assessment methods and nationally representative data to estimate the impact of all major modifiable risk factors on mortality and morbidity in the United States in 1990 and in 2010.[133] Suboptimal dietary habits were the leading cause of both mortality and DALY lost, exceeding even tobacco. In 2010, a total of 678 000 deaths of all causes were attributable to suboptimal diet.
- A previous investigation reported the estimated mortality effects of several specific dietary risk factors in 2005 in the United States. High dietary salt consumption was estimated to be responsible for 102 000 annual deaths, low dietary omega-3 fatty acids for 84 000 annual deaths, high dietary *trans* fatty acids for 82 000 annual deaths, and low consumption of fruits and vegetables for 55 000 annual deaths.[134]

Cost

(See Chart 5-8.)

The US Department of Agriculture forecast that the Consumer Price Index for all food would increase 3.0% to 4.0% in 2013 as retailers continued to pass on higher commodity and energy costs to consumers in the form of higher retail prices. The Consumer Price Index for food increased 3.7% in 2011. Prices for foods eaten at home increased 4.8% in 2011, whereas prices for foods eaten away from home increased by 1.9%.[135]

- A meta-analysis of price comparisons of healthier versus unhealthier diet patterns found that the healthiest diet patterns cost, on average, ≈$1.50 more per person per day to consume.[136]
- In an assessment of snacks served at YMCA afterschool programs from 2006 to 2008, healthful snacks were ≈50% more expensive ($0.26 per snack) than less healthful snacks.[137] Higher snack costs were driven by serving fruit juice compared with water; serving refined grains without *trans* fat compared with refined grains with *trans* fats; and serving fruit and canned or frozen vegetables. Serving fresh vegetables (mostly carrots or celery) or whole grains did not alter price.
- As a proportion of income, food has become less expensive over time in the United States. As a share of personal disposable income, average (mean) total food expenditures by families and individuals have decreased from 22.3% (1949) to 18.1% (1961) to 14.9% (1981) to 11.3% (2011). For any given year, the share of disposable income spent on food is inversely proportional to absolute income. The share increases as absolute income levels decline.[135]
- The proportion of total US food expenditures for meals outside the home, as a share of total food dollars, increased from 27% in 1961 to 40% in 1981 to 49% in 2011.[64]
- The proportion of sales of meals and snacks from fast-food restaurants, compared with total meals and snacks away from home, increased from 5% in 1958 to 29% in 1982 to 36% in 2011.[135]
- Among 153 forms of fruits and vegetables priced with 2008 Nielsen Homescan data, price and calorie per portion of 20 fruits and vegetables were compared with 20 common snack foods, such as cookies, chips, pastries, and crackers. Average price per portion of fruits and vegetables was 31 cents, with an average of 57 calories per portion, compared with 33 cents and 183 calories per portion for snack foods.[135]
- An overview of the costs of various strategies for primary prevention of CVD determined that the estimated costs per year of life gained were between $9800 and $18 000 for statin therapy, $1500 for nurse screening and lifestyle advice, $500 to $1250 for smoking cessation, and $20 to $900 for population-based healthy eating.[138]
- year, >$33 billion in medical costs and $9 billion in lost productivity resulting from HD, cancer, stroke, and DM are attributed to poor nutrition.[139–142]
- Two separate cost-effectiveness analyses estimated that population reductions in dietary salt would not only be cost-effective but actually cost-saving.[143,144] In 1 analysis, a 1.2-g/d reduction in dietary sodium was projected to reduce US annual cases of incident CHD by 60 000 to 120 000, stroke by 32 000 to 66 000, and total mortality by 44 000 to 92 000.[144] If accomplished through a regulatory intervention, estimated savings in healthcare costs would be $10 to $24 billion annually.[144] Such an intervention would be more cost-effective than using medications to lower BP in all people with hypertension.

Table 5-1. AHA Dietary Targets and Healthy Diet Score for Defining Cardiovascular Health

	AHA Target	Consumption Range for Alternative Healthy Diet Score*	Alternative Scoring Range*
Primary dietary metrics†			
Fruits and vegetables	≥4.5 cups/d‡	0 to ≥4.5 cups/d‡	0–10
Fish and shellfish	2 or more 3.5-oz servings/wk (≥200 g/wk)	0 to ≥7 oz/wk	0–10
Sodium	≤1500 mg/d	≤1500 to >4500 mg/d	10–0
SSBs	≤36 fl oz per week	≤36 to >210 fl oz/wk	10–0
Whole grains	3 or more 1-oz-equivalent servings/d	0 to ≥3 oz/d	0–10
Secondary dietary metrics†			
Nuts, seeds, and legumes	≥4 servings/wk (nuts/seeds: 1 oz; legumes: ½ cup)	0 to ≥4 servings/d	0–10
Processed meats	2 or fewer 1.75-oz servings/wk (≤100 g/wk)	≤3.5 to >17.5 oz/wk	10–0
Saturated fat	≤7% energy	≤7 to >15 (% energy)	10–0
AHA Diet Score (primary)	Ideal: 4 or 5 dietary targets (≥80%) Intermediate: 2 or 3 dietary targets (40%–79%) Poor: <2 dietary targets (<40%)	Sum of scores for primary metrics	0 (worst) to 100 (best)§ Ideal: 80–100 Intermediate: 40–79 Poor:<40
AHA Diet Score (secondary)	Ideal: 4 or 5 dietary targets (≥80%) Intermediate: 2 or 3 dietary targets (40%–79%) Poor: <2 dietary targets (<40%)	Sum of scores for primary and secondary metrics	0 (worst) to 100 (best)§ Ideal: 80–100 Intermediate: 40–79 Poor:<40

AHA indicates American Heart Association; and SSBs, sugar-sweetened beverages.

*Consistent with other dietary pattern scores, the highest score (10) was given for meeting or exceeding the AHA target (eg, at least 4.5 cups of fruits and vegetables per day; no more than 1500 mg/d of sodium), and the lowest score (0) was given for zero intake (protective factors) or for very high intake (harmful factors). The score for each metric was scaled continuously within this range. For harmful factors, the level of high intake that corresponded to a zero score was identified as approximately the 90th percentile distribution of US population intake.

†Selected by the AHA based on evidence for likely causal effects on cardiovascular events, diabetes mellitus, or obesity; a general prioritization of food rather than nutrient metrics; consistency with US and AHA dietary guidelines; ability to measure and track these metrics in the US population; and parsimony, that is, the inclusion of as few components as possible that had minimal overlap with each other while at the same time having some overlap with the many other relevant dietary factors that were not included.[2] The AHA dietary metrics should be targeted in the context of a healthy diet pattern that is appropriate in energy balance and consistent with a DASH (Dietary Approaches to Stop Hypertension)-type eating plan, including but not limited to these metrics.

‡Including up to one 8-oz serving per day of 100% fruit juice and up to 0.42 cups/d (3 cups/wk) of starchy vegetables such as potatoes or corn.

§The natural range of the primary AHA Diet Score is 0 to 50 (5 components), and the natural range of the secondary AHA Diet Score is 0 to 80 (8 components). Both scores are then rescaled to a range of 0 to 100 for comparison purposes. The ideal range of the primary AHA Diet Score corresponds to the AHA scoring system of meeting at least 4 of 5 binary dietary targets (≥80%), the intermediate range corresponds to meeting 2 or 3 dietary targets (40%–79%), and the poor range corresponds to meeting <2 dietary targets (<40%). The same ranges are used for the secondary AHA Diet Score for consistency and comparison.

Table 5-2. Dietary Consumption of Selected Foods and Nutrients Related to Cardiometabolic Health Among US Adults ≥20 Years of Age in 2011 to 2012[110,120,145,146]

	NH White Men		NH White Women		NH Black Men		NH Black Women		Mexican American Men		Mexican American Women	
	Average Consumption	% Meeting Guidelines*	Average Consumption	% Meeting Guidelines*	Average Consumption	% Meeting Guidelines*	Average Consumption	% Meeting Guidelines*	Average Consumption	% Meeting Guidelines*	Average Consumption	% Meeting Guidelines*
Foods												
Whole grains, servings/d	1.1±1.0	9.0	1.1±0.8	7.3	0.9±1.2	7.7	0.8±0.7	4.8	0.6±0.5	3.9	0.8±0.7	6.1
Total fruit, servings/d	1.5±0.8	9.2	1.6±1.6	9.2	1±1.3	6.9	1.2±1.3	6.8	1.4±1.4	6.6	1.4±1.0	5.7
Total fruits including 100% juices, servings/d	2.0±1.7	15.3	2.2±1.9	14	2±1.8	15.8	2±1.3	14	1.9±1.5	16.4	2.1±1.5	14.5
Nonstarchy vegetables, servings/d	2.3±2.0	7.9	2.7±1.6	12.4	1.7±1.0	4.3	2.0±1.3	5.9	2.0±0.7	3.2	2.5±0.5	7.7
Starchy vegetables, servings/d†	0.9±0.3	NA	0.8±0.3	NA	0.9±0.5	NA	0.9±0.4	NA	0.7±0.2	NA	0.7±0.3	NA
Legumes, servings/d	1.6±1.4	22.1	1.1±0.7	14.4	1.1±1.1	12.8	1.1±1.2	13.3	4.7±4.0	47.4	2.3±2.6	24.8
Fish and shellfish, servings/wk	1.1±1.1	16.7	1.0±0.9	16.5	1.7±2.7	23.3	1.9±0.9	26.7	1.7±1.7	19.7	0.8±0.1	14.6
Nuts and seeds, servings/wk	3.5±5.9	23.7	3.6±3.3	24.0	2.2±3.4	16.2	2.8±8.6	16.0	2.4±1.6	12.4	2.6±3.8	11.8
Unprocessed red meat, servings/wk	3.6±1.6	NA	2.5±1.3	NA	3.1±0.8	NA	2.6±1.3	NA	4.8±0.6	NA	3.2±1.5	NA
Processed meats, servings/wk	2.4±1.4	57.4	1.6±1.0	69.5	2.5±1.5	55	1.8±0.6	65.6	1.7±1.1	68.9	1.1±0.5	78.9
Sugar-sweetened beverages, servings/wk	9.1±11.0	50.9	6.8±8.3	65.4	11.1±8.9	32.3	11±8.0	33.9	11.7±7.7	32.7	8.4±6.6	42.7
Sweets and bakery desserts, servings/wk	6.4±3.6	33.1	7.3±4.1	31.8	5.8±4.0	42.7	6.4±3.0	37.4	3.9±2.5	54.0	5.8±0.6	38.5
Nutrients												
Total calories, kcal/d	2482±551	NA	1789±421	NA	2354±682	NA	1853±514	NA	2576±506	NA	1848±467	NA
EPA/DHA, g/d	0.083±0.053	7.4	0.074±0.054	6.4	0.101±0.08	9.9	0.110±0.10	13.7	0.117±0.075	10.7	0.058±0.037	4.0
ALA, g/d	1.58±0.35	41.9	1.75±0.38	85.0	1.51±0.37	35.5	1.72±0.43	83.1	1.57±0.46	41.2	1.66±0.22	81.9
n-6 PUFA, % energy	7.0±1.4	NA	7.3±1.5	NA	7.2±1.2	NA	7.8±1.6	NA	6.8±1.4	NA	7.0±0.5	NA
Saturated fat, % energy	11.0±1.8	36.3	10.7±1.8	43.1	10.2±1.8	47.1	10.3±1.5	46.3	10.7±1.4	42.0	10.9±2.4	46.9
Dietary cholesterol, mg/d	281±177	67.7	256±180	71.4	322±193	58.9	299±176	63.1	343±216	51.6	290±221	68.7
Total fat, % energy	33.7±5.3	52.7	33.2±4.6	58.8	33.2±4.8	58.3	33.9±4.0	51.1	33.1±3.8	63.9	33.5±3.6	56.6
Carbohydrate, % energy	47.9±7.7	NA	49.8±7.2	NA	48.1±7.2	NA	50±4.9	NA	49.1±4.4	NA	50.5±5.7	NA
Dietary fiber, g/d	17.2±6.3	7.3	18.4±6.2	10.3	14.3±4.6	3.7	15.2±4.6	5.3	19.3±5.9	13.4	18.9±5.8	14.2
Sodium, g/d	3.4±0.49	6.7	3.4±0.62	6.4	3.4±0.43	6.4	3.5±0.63	8.4	3.4±0.48	8.4	3.5±0.63	8.4

Values for average consumption are mean±SD. Data are from the National Health and Nutrition Examination Survey 2011 to 2012, derived from two 24-hour dietary recalls per person, with population standard deviations adjusted for within-person vs between-person variation (analyses courtesy of Dr Colin Rehm, Tufts University). All values are energy adjusted by individual regressions or percent energy, and for comparability, means and proportions are reported for a 2000-kcal/d diet. To obtain actual mean consumption levels, the group means for each food or nutrient can be multiplied by the group-specific total calories (kcal/d) divided by 2000 kcal/d. Compared with 2014 and earlier American Heart Association Statistical Updates, the calculations for foods now use the US Department of Agriculture's (USDA) Food Patterns Equivalent Database on composition of various mixed dishes, which incorporates partial amounts of various foods (eg, vegetables, nuts, processed meats) in mixed dishes; in addition, the characterization of whole grains is now derived from the USDA database instead of the ratio of total carbohydrate to fiber.

ALA indicates α-linoleic acid; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; NA, not available; NH, non-Hispanic; and n-6-PUFA, ω-6-polyunsaturated fatty acid.

*All intakes and guidelines adjusted to a 2000 kcal/d diet. Servings defined as follows: whole grains, 1-oz equivalents; fruits and vegetables, 1/2-cup equivalents; legumes, 1/2 cup; fish/shellfish, 3.5 oz or 100 g; nuts and seeds, 1 oz; unprocessed red or processed meat, 3.5 oz or 100 g; sugar-sweetened beverages, 8 fl oz; sweets and bakery desserts, 50 g. Guidelines defined as follows: whole grains, 3 or more 1-oz equivalent (eg, 21 g whole wheat bread, 82 g cooked brown rice, 31 g Cheerios) servings/d[147]; fruits, 2 or more cups/d[141]; nonstarchy vegetables, 2 1/2 or more cups/d[141]; legumes, 1.5 or more cups/wk[147]; fish or shellfish, 2 or more 100-g (3.5-oz) servings/wk[147]; nuts and seeds, 4 or more 1-oz servings/wk[147]; processed meats (bacon, hot dogs, sausage, processed deli meats), 2 or fewer 100-g (3.5-oz) servings/wk (1/4 of discretionary calories)[141]; sugar-sweetened beverages (defined as ≥50 cal/8 oz, excluding 100% fruit juices), ≤36 oz/wk (≈1/4 of discretionary calories)[141,147]; sweets and bakery desserts, 2.5 or fewer 50-g servings/wk (≈1/4 of discretionary calories)[141,147]; EPA/DHA, ≥0.250 g/d[148]; ALA, ≥1.6/1.1 g/d (men/women)[142]; saturated fat, <10% energy; dietary cholesterol, <300 mg/d[141]; total fat, 20% to 35% energy[141]; dietary fiber, ≥28/d[141]; and sodium, <2.3 g/d.[141] No dietary targets are listed for starchy vegetables and unprocessed red meats because of their positive association with long-term weight gain and their positive or uncertain relation with diabetes mellitus fand cardiovascular disease.

†Including white potatoes (chips, fries, mashed, baked, roasted, mixed dishes), corn, plantain, green peas, etc. Sweet potatoes, pumpkin, and squash are considered red-orange vegetables by the USDA and are included in nonstarchy vegetables.

Table 5-3. Dietary Consumption of Selected Foods and Nutrients Related to Cardiometabolic Health Among US Children and Teenagers in 2011 to 2012

	Boys (5–9 y)		Girls (5–9 y)		Boys (10–14 y)		Girls (10–14 y)		Boys (15–19 y)		Girls (15–19 y)	
	Average Consumption	% Meeting Guidelines*	Average Consumption	% Meeting Guidelines*	Average Consumption	% Meeting Guidelines*	Average Consumption	% Meeting Guidelines*	Average Consumption	% Meeting Guidelines*	Average Consumption	% Meeting Guidelines*
Foods												
Whole grains, servings/d	0.9±0.4	2.2	0.9±0.5	2.8	0.8±0.4	3.8	0.7±0.4	2.5	0.9±0.8	4.7	0.9±0.3	4.1
Fruits, servings/d	1.7±1.1	8.3	1.9±1.4	13.7	1.4±0.9	8.3	1.4±0.8	3.3	1.3±1.1	6.1	0.9±0.8	4.7
Fruits including 100% fruit juice, servings/d	2.7±1.3	22.3	2.7±1.5	23.1	2.1±1.2	16.3	2.0±1.1	16.5	2.0±0.4	14.3	1.6±1.2	11.2
Nonstarchy vegetables, servings/d	1.1±0.8	0.9	1.1±0.7	0.0	1.2±0.6	1.3	1.2±0.7	1.1	1.4±0.4	0.5	1.5±0.1	1.2
Starchy vegetables, servings/d †	0.6±0.2	NA	0.7±0.2	NA	0.7±0.3	NA	0.7±0.3	NA	0.8±0.6	NA	0.7±0.3	NA
Legumes, servings/d	1.2±1.7	14.2	0.7±0.8	9.2	1.0±1.0	13.9	1.2±1.5	16.6	1.3±1.4	15.4	0.9±0.4	9.6
Fish/shellfish, servings/wk	1.0±1.0	14.3	0.5±0.7	7.2	0.3±0.3	6.7	0.4±0.3	7.7	0.6±1.3	10.8	0.9±0.6	11.9
Nuts and seeds, servings/wk	2.3±4.6	15.4	2.1±1.5	13.3	1.1±0.8	6.4	1.3±0.2	10.9	1.8±1.3	17.4	2.7±2.0	12.9
Unprocessed red meats, servings/wk	1.7±0.7	NA	1.6±1.1	NA	2.3±1.5	NA	1.9±1.1	NA	3.6±1.8	NA	2.5±1.5	
Processed meats, servings/wk	2.0±0.5	54.1	1.6±1.0	63.9	2.0±0.5	64.4	1.6±0.2	70.3	2.3±1.5	57.7	1.4±1.0	75.4
Sugar-sweetened beverages, servings/wk	7.7±6.2	44.2	6.0±3.8	52.5	11.6±5.3	20.7	9.7±7.9	37.8	12.4±5.8	24.5	14±6.0	32.8
Sweets and bakery desserts, servings/wk	8.0±1.8	27.0	7.7±2.8	15.5	8.3±4.5	29.1	6.6±2.5	31.2	4.7±3.5	42.0	6.0±3.5	38.7
Nutrients												
Total calories, kcal/d	2048±457	NA	1767±238	NA	2145±497	NA	1745±343	NA	2444±664	NA	1838±287	NA
EPA/DHA, g/d	0.063±0.052	5.7	0.041±0.024	2.1	0.034±0.028	1.8	0.034±0.025	2.1	0.065±0.092	6.3	0.055±0.045	5.2
ALA, g/d	1.39±0.21	26.4	1.41±0.17	76.7	1.36±0.11	29.0	1.45±0.16	72.7	1.45±0.16	33.9	1.54±0.17	76.5
n-6 PUFA, % energy	6.4±1.2	NA	6.7±1.2	NA	6.5±1.0	NA	6.7±1.2	NA	6.8±1.3	NA	7.1±0.8	NA
Saturated fat, % energy	11.7±1.6	23.7	11.3±0.8	30.4	11.0±1.6	31.0	11.4±2.2	30.0	10.8±1.3	40.3	10.9±0.6	39.9
Dietary cholesterol, mg/d	215±144	80.1	212±142	79.8	242±175	77.7	226±149	78.9	269±152	67.9	269±200	74.1
Total fat, % energy	33±4.1	66.3	33±2.7	63.5	31.9±3.1	69.0	32.6±0.6	60.6	32.5±3.8	57.8	32.6±2.9	66.1
Carbohydrate, % energy	53.9±2.7	NA	53.9±1.5	NA	54.7±4.0	NA	54±3.8	NA	51.8±3.0	NA	53.2±3.3	NA
Dietary fiber, g/d	15.1±2.8	1.8	15.9±2.9	1.0	14.9±3.3	2.0	15.4±2.8	1.2	15.7±3.9	2.8	14.4±3.4	1.0
Sodium, g/d	3.2±0.41	7.2	3.1±0.40	11.1	3.3±0.28	4.4	3.4±0.49	7.9	3.5±0.32	3.0	3.5±0.52	2.4

Values for average consumption are mean±SD. Data are from the National Health and Nutrition Examination Survey 2011 to 2012, derived from two 24-hour dietary recalls per person, with population standard deviations adjusted for within-person vs between-person variation (analyses courtesy of Dr Colin Rehm, Tufts University). All values are energy adjusted by individual regressions or percent energy, and for comparability, means and proportions are reported for a 2000-kcal/d diet. To obtain actual mean consumption levels, the group means for each food or nutrient can be multiplied by the group-specific total calories (kcal/d) divided by 2000 kcal/d. Compared with 2014 and earlier American Heart Association Statistical Updates, the calculations for foods now use the US Department of Agriculture's (USDA) Food Patterns Equivalent Database on composition of various mixed dishes, which incorporates partial amounts of various foods (eg, vegetables, nuts, processed meats) in mixed dishes; in addition, the characterization of whole grains is now derived from the USDA database instead of the ratio of total carbohydrate to fiber.

ALA indicates α-linoleic acid; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; NA, not available; and n-6-PUFA, ω-6-polyunsaturated fatty acid.

*All intakes and guidelines adjusted to 2000 kcal/d diet. Servings defined as follows: whole grains, 1-oz equivalents; fruits and vegetables, 1/2-cup equivalents; legumes, 1/2 cup; fish/shellfish, 3.5 oz or 100 g; nuts and seeds, 1 oz; unprocessed red or processed meat, 3.5 oz or 100 g; sugar-sweetened beverages, 8 fl oz; sweets and bakery desserts, 50 g. Guidelines defined as follows: whole grains, 3 or more 1-oz equivalent (eg, 21 g whole wheat bread, 82 g cooked brown rice, 31 g Cheerios) servings/d[147]; fruits, 2 or more cups/d[141]; nonstarchy vegetables, 2 1/2 or more cups/d[141]; legumes, 1.5 or more cups/wk[147]; fish or shellfish, 2 or more 100-g (3.5-oz) servings/wk[147]; nuts and seeds, 4 or more 1-oz servings/wk[147]; processed meats (bacon, hot dogs, sausage, processed deli meats), 2 or fewer 100-g (3.5-oz) servings/wk (1/4 of discretionary calories)[141]; sugar-sweetened beverages (defined as ≥50 cal/8 oz, excluding 100% fruit juices), ≤36 oz/wk (≈1/4 of discretionary calories)[141,147]; sweets and bakery desserts, 2.5 or fewer 50-g servings/wk (≈1/4 of discretionary calories)[141,147]; EPA/DHA, ≥0.250 g/d[148]; ALA, ≥1.6/1.1 g/d (men/women)[142]; saturated fat, <10% energy; dietary cholesterol, <300 mg/d[141]; total fat, 20% to 35% energy[141]; dietary fiber, ≥28/d[141]; and sodium, <2.3 g/d.[141] No dietary targets are listed for starchy vegetables and unprocessed red meats because of their positive association with long-term weight gain and their positive or uncertain relation with diabetes mellitus and cardiovascular disease.

†Including white potatoes (chips, fries, mashed, baked, roasted, mixed dishes), corn, plantain, green peas, etc. Sweet potatoes, pumpkin, and squash are considered red-orange vegetables by the USDA and are included in nonstarchy vegetables.

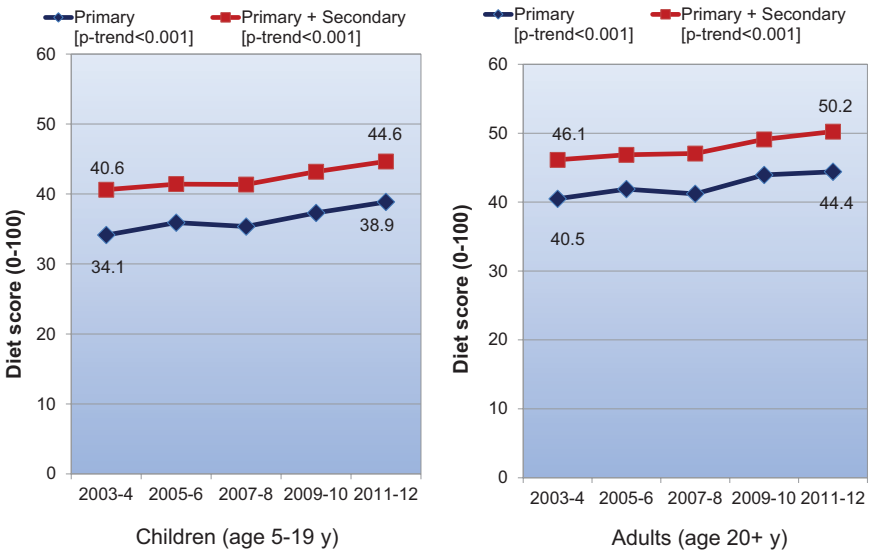

Chart 5-1. Trends in mean healthy diet scores for children and adults, National Health and Nutrition Examination Survey 2003 to 2004 through 2011 to 2012. Primary metrics include fruits/vegetables, whole grains, fish, sugar-sweetened beverages, and sodium. Secondary metrics include nuts, seeds, and legumes; processed meats; and saturated fats. Components of poor, intermediate, and ideal diet are defined in Table 5-1. Mean healthy diet scores based on the alternative scoring ranges described in Table 5-1.

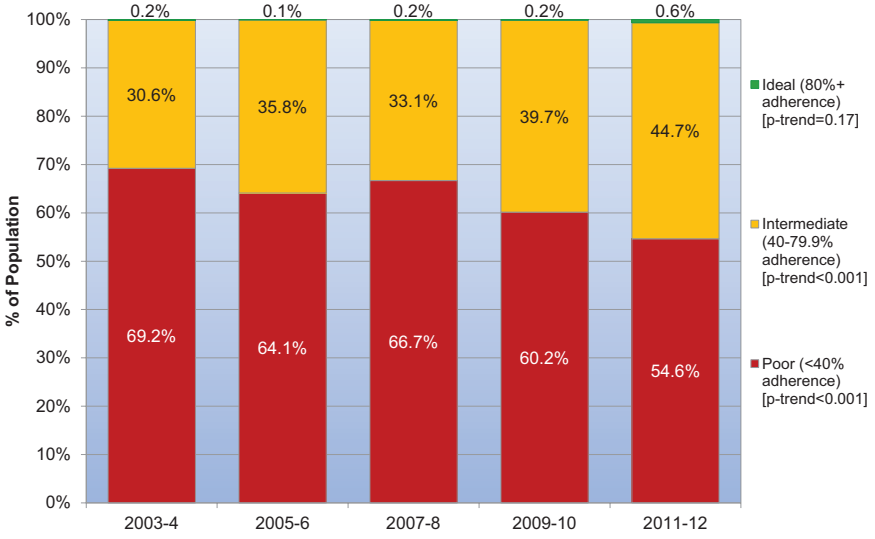

Chart 5-2. Healthy diet targets in children (5–19 years old) by survey year: National Health and Nutrition Examination Survey 2003 to 2004, 2005 to 2006, 2007 to 2008, 2009 to 2010, and 2011 to 2012. Components of poor, intermediate, and ideal diet are defined in Table 5-1. Percentages based on the alternative scoring ranges described in Table 5-1.

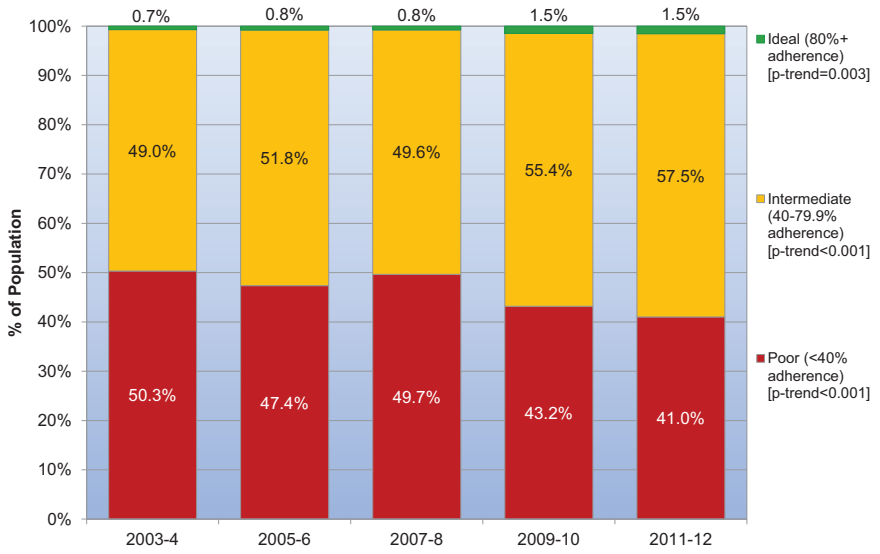

Chart 5-3. Healthy diet targets in adults (≥20 years of age) by survey year: National Health and Nutrition Examination Survey 2003 to 2004, 2005 to 2006, 2007 to 2008, 2009 to 2010, and 2011 to 2012. Components of poor, intermediate, and ideal diet are defined in Table 5-1. Percentages based on the alternative scoring ranges described in Table 5-1.

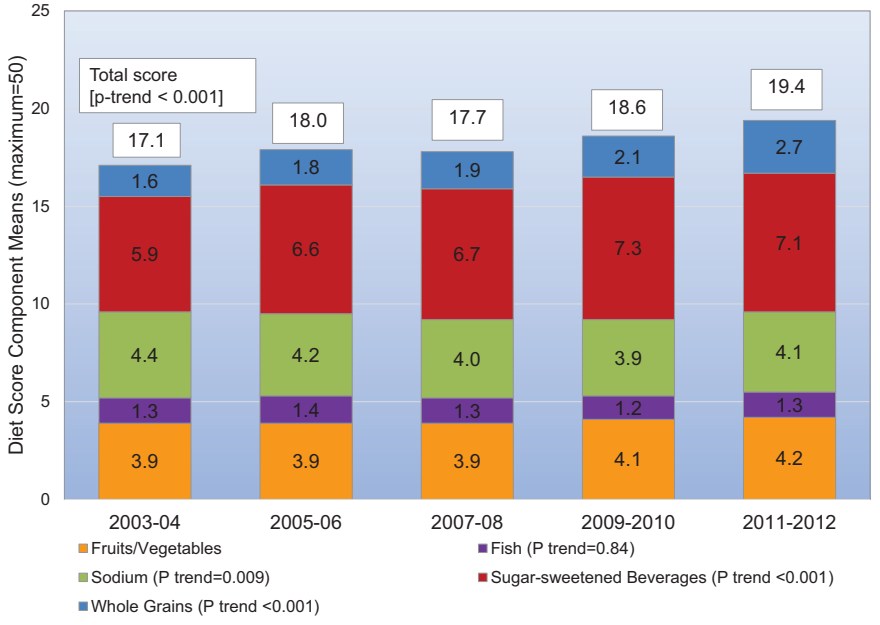

Chart 5-4. Trends in American Heart Association (AHA) defined healthy diet score components for children (5–19 years old) by survey year: National Health and Nutrition Examination Survey 2003 to 2004, 2005 to 2006, 2007 to 2008, 2009 to 2010, and 2011 to 2012. Unscaled dietary score (maximum=50). Mean healthy diet score components based on the alternative scoring ranges described in Table 5-1.

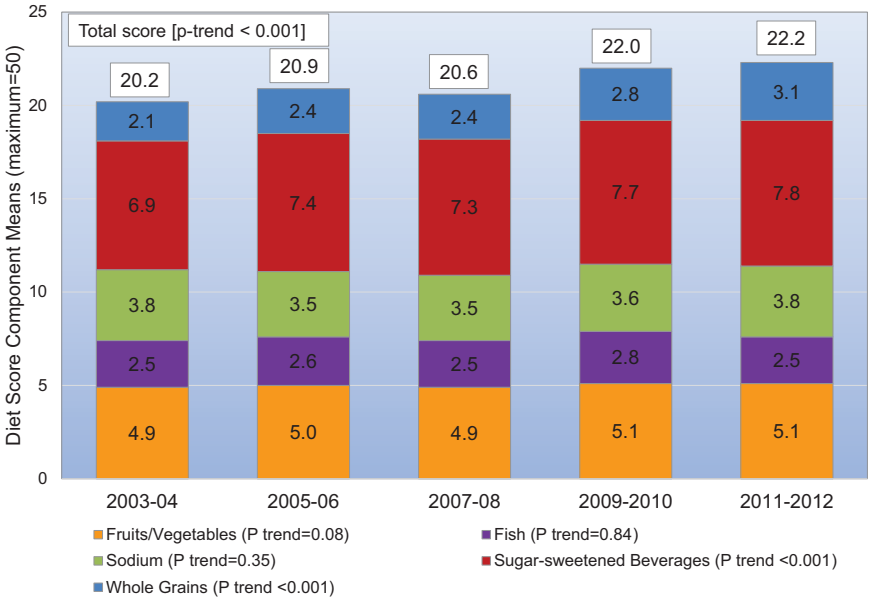

Chart 5-5. Trends in American Heart Association (AHA) healthy diet score components for adults (≥20 years of age) by survey year: National Health and Nutrition Examination Survey 2003 to 2004, 2005 to 2006, 2007 to 2008, 2009 to 2010, and 2011 to 2012. Unscaled dietary score (maximum=50). Mean healthy diet score components based on the scoring ranges described in Table 5-1.

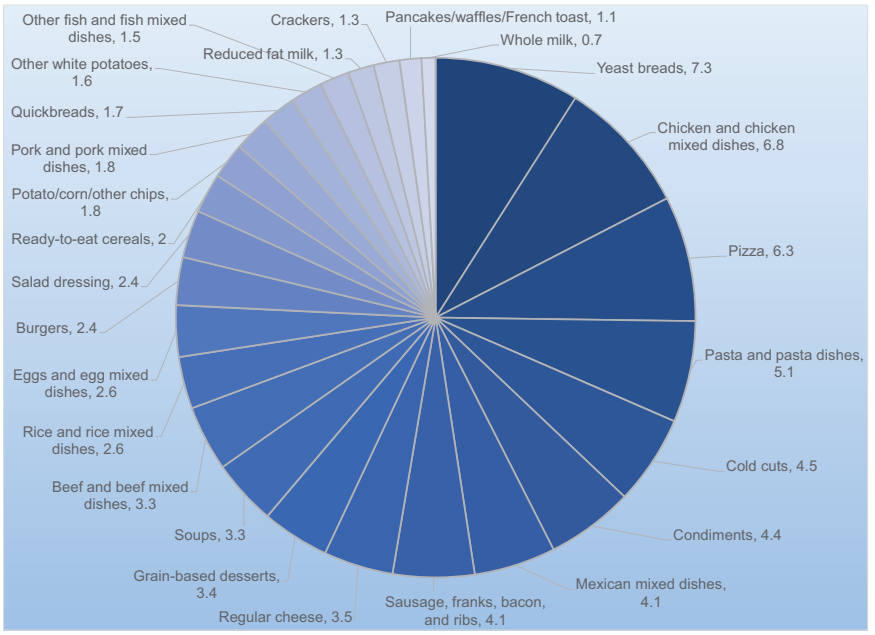

Chart 5-6. Percentage of sodium from dietary sources in the United States, 2005 to 2006. Source: Applied Research Program, National Cancer Institute.[149]

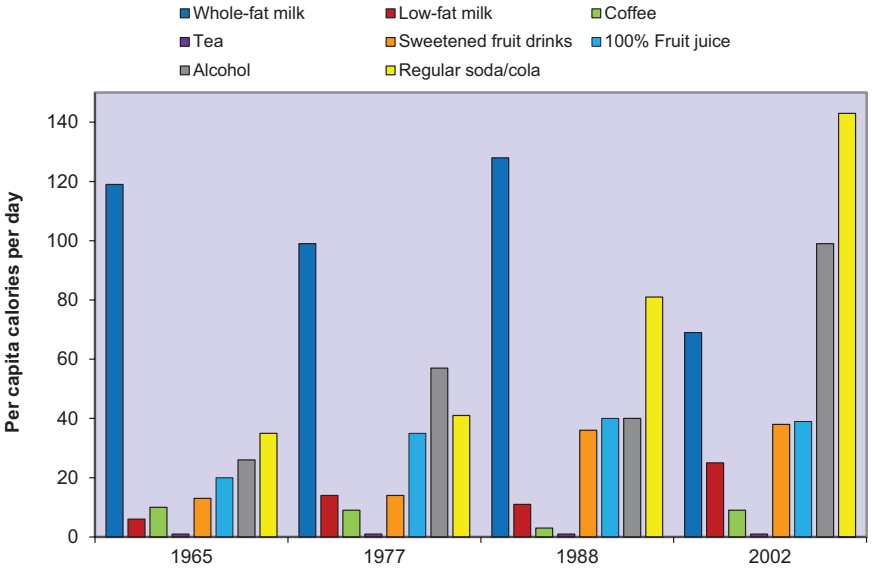

Chart 5-7. Per capita calories consumed from different beverages by US adults (≥19 years of age), 1965 to 2010. Source: Nationwide Food Consumption Surveys (1965, 1977–1978) and National Health and Nutrition Examination Survey (1988–2010), based on data from Duffey and Popkin[23]and Kit et al.[68] Data from 2010 were only analyzed for soda/cola and sweetened fruit drinks.

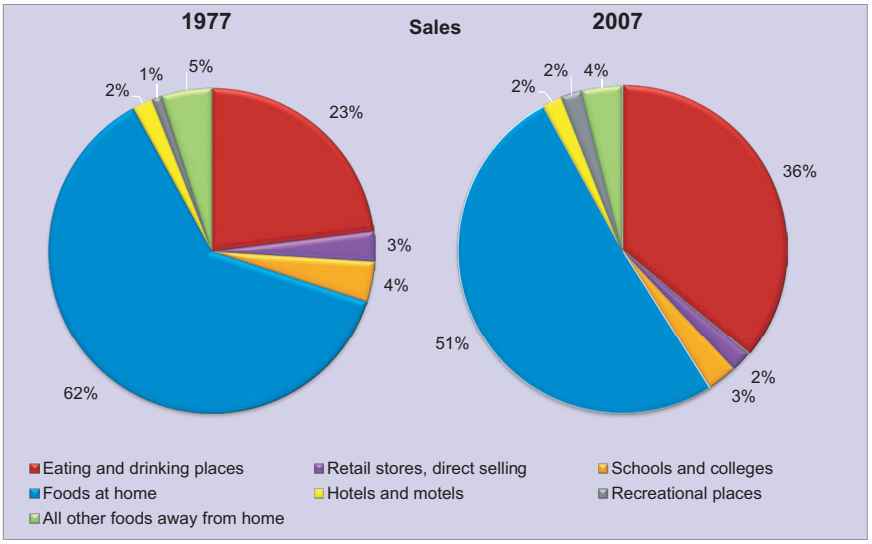

Chart 5-8. Total US food expenditures away from home and at home, 1977 and 2007. Data derived from Davis et al.[64]

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6. Overweight and Obesity

See Table 6-1 and Charts 6-1 through 6-3.

Overweight and obesity are major risk factors for CVD, including CHD, stroke,[1,2] AF,[3] VTE,[4] and CHF. The AHA has identified BMI <85th percentile (ages 2–19 years) and <25 kg/m^2 (ages ≥20 years) as 1 of the 7 components of ideal cardiovascular health.[5] In 2011 to 2012, 64.7% of children and 31.3% of adults met these criteria (Chapter 2, Cardiovascular Health).

Classification of Overweight and Obesity

- For adults, *overweight* (not including obese) is defined as 25.0 ≤ BMI ≤ 29.9 kg/m^2, and *obese* is defined as BMI ≥30.0 kg/m^2. Obesity for adults is often further classified by grade of obesity: class I obesity is BMI 30 to 34.9 kg/m^2, class II is BMI 35 to 39.9 kg/m^2, and class III is BMI ≥40 kg/m^2.[6] For children, when sex-specific BMI-for-age 2000 CDC growth charts for the United States are used,[7] *overweight* is defined as 85th to <95th percentile, and *obese* is defined as ≥95th percentile. These categories were previously called "at risk for overweight" and "overweight." The newer terminology reflects the labels used by organizations such as the Institute of Medicine and the American Academy of Pediatrics. More information is available in Ogden and Flegal's "Changes in terminology for childhood overweight and obesity."[8]
- A recent AHA scientific statement recommended that the definition of severe obesity for children ≥2 years old and adolescents be changed to BMI ≥120% of the 95th percentile for age and sex, or an absolute BMI ≥35 kg/m, whichever is lower.[9] This definition of severe obesity among children may better identify this small but important group than the other common definition of BMI ≥99th percentile for age and sex.[9]
- There are other methods to classify excess adiposity, such as waist circumference, which is also associated with increased cardiovascular risk.[10] Recent obesity guidelines define waist circumference ≥40 inches (102 cm) for men and ≥35 inches (88 cm) for women as elevated. Waist circumference measurement is recommended for those with BMI of 25 to 34.9 kg/m^2, to provide additional information on CVD risk, but may be unnecessary among those with BMI ≥35 kg/m^2, who are unlikely to have waist circumference less than these cutoffs.[6]

Prevalence

Youth

(See Table 6-1 and Chart 6-1.)

- According to 2011 to 2012 data from NHANES (NCHS), the overall prevalence of overweight, including obesity, in children and adolescents aged 2 to 19 years was 31.8% based on a BMI-for-age value ≥85th percentile of the 2000

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Abbreviations Used in Chapter 6

AF	atrial fibrillation
AFFIRM	Atrial Fibrillation Follow-up Investigation of Rhythm Management
AHA	American Heart Association
ARIC	Atherosclerosis Risk in Communities Study
BMI	body mass index
BP	blood pressure
BRFSS	Behavioral Risk Factor Surveillance System
CAC	coronary artery calcification
CAD	coronary artery disease
CARDIA	Coronary Artery Risk Development in Young Adults
CDC	Centers for Disease Control and Prevention
CHD	coronary heart disease
CHF	congestive heart failure
CI	confidence interval
CVD	cardiovascular disease
DALY	disability-adjusted life-year
DM	diabetes mellitus
HbA_{1c}	hemoglobin A_{1c}
HDL-C	high-density lipoprotein cholesterol
HR	hazard ratio
HUNT 2	Nord-Trøndelag Health Study
IMT	intima-media thickness
LABS	Longitudinal Assessment of Bariatric Surgery
MEPS	Medical Expenditure Panel Survey
MESA	Multi-Ethnic Study of Atherosclerosis
MI	myocardial infarction
NCDR	National Cardiovascular Data Registry
NCHS	National Center for Health Statistics
NH	non-Hispanic
NHANES	National Health and Nutrition Examination Survey
NHDS	National Hospital Discharge Survey
NHIS	National Health Interview Survey
NHLBI	National Heart, Lung, and Blood Institute
OR	odds ratio
PA	physical activity
RR	relative risk
RYGB	Roux-en-Y gastric bypass
SBP	systolic blood pressure
SD	standard deviation
SOS	Swedish Obese Subjects
STEMI	ST-segment–elevation myocardial infarction
TC	total cholesterol
Teen-LABS	Teen Longitudinal Assessment of Bariatric Surgery
UI	uncertainty interval
VTE	venous thromboembolism
WHI	Women's Health Initiative
WHO	World Health Organization

CDC growth charts. By age group, the prevalence for children aged 2 to 5 years was 22.8%; for children aged 6 to 11 years, prevalence was 34.2%; and for adolescents aged 12 to 19 years, prevalence was 34.5%. There were no significant differences in overweight (including obesity) prevalence for boys and girls. Among all children aged 2 to 19 years, the prevalence of overweight (including obesity) was lower for non-Hispanic Asian children than for non-Hispanic white, non-Hispanic black, and Hispanic children. However, this effect did not hold for all age groups (2–5, 6–11, and 12–19 years old).[11]

- According to 2011 to 2012 data from NHANES (NCHS), the overall prevalence of obesity in children and adolescents aged 2 to 19 years was 16.9% based on a BMI-for-age value ≥95th percentile of the 2000 CDC growth charts. By age group, the prevalence for children aged 2 to 5 years was 8.4%; for children aged 6 to 11 years, prevalence was 17.7%; and for adolescents aged 12 to 19 years, prevalence was 20.5%. In this period, there were no significant differences in obesity prevalence for boys and girls. Among all children aged 2 to 19 years, the prevalence of obesity was lower for non-Hispanic Asian and non-Hispanic white children than for non-Hispanic black and Hispanic children.[11]
- The prevalence of childhood obesity varies by socioeconomic status. According to 1999 to 2008 NHANES survey data, lowest-income girls (ages 12–17 years) had an obesity prevalence of 17.9% compared with 13.1% among those with higher income; similar observations were observed for boys (20.6% versus 15.6%, respectively).[12]
- In addition, obesity prevalence among adolescents is higher for those whose parents had a high school degree or less education than for adolescents whose parents had a bachelor's degree or higher.[13]
- According to one analysis of NHANES 2011 to 2012 data, 5.9% of children aged 2 to 19 years had severe, or class II, obesity, defined as BMI ≥120% of the 95th percentile for age and sex, or BMI ≥35 kg/m^2, and 2.1% had BMI ≥140% of the 95th percentile for age and sex, or BMI ≥40 kg/m^2.[14]

Adults

(See Table 6-1 and Chart 6-2.)

- According to NHANES 2009 to 2012 (unpublished NHLBI tabulations using measured height and weight):
  - —Overall, 69% of US adults were overweight, including obese (73% of men and 65% of women).
  - —Among men, Hispanics (80%) and non-Hispanic whites (73%) were more likely to be overweight, including obese, than non-Hispanic blacks (69%).
  - —Among women, non-Hispanic blacks (82%) and Hispanics (76%) were more likely to be overweight, including obese, than non-Hispanic whites (61%).
  - —Among US adults, 35% were obese (34% of men and 36% of women).
  - —Among men, Hispanics and non-Hispanic blacks (38%) were more likely to be obese than non-Hispanic whites (34%).
  - —Among women, non-Hispanic blacks (58%) and Hispanics (43%) were more likely to be obese than non-Hispanic whites (33%).
- As estimated from self-reported height and weight in the BRFSS/CDC survey in 2013, the prevalence of obesity ranged from 21.3% in Colorado to 35.1% in West Virginia and Mississippi. These estimates are based on self-report rather than measured height and weight; self-reported estimates usually underestimate BMI and obesity.[15]

Trends

Youth

(See Chart 6-3.)

- Among infants and children between 6 and 23 months of age, the prevalence of high weight for recumbent length (ie, ≥ 97.7th percentile of WHO weight for recumbent length growth standards) was 7% in 1976 to 1980, 12% in 2003 to 2006 (NHANES, NCHS),[16] and 8% in 2011 to 2012 (NHANES).[11]
- According to NHANES data, between 2003 to 2004 and 2011 to 2012, overall obesity prevalence in youth aged 2 to 19 years was unchanged, although among children aged 2 to 5 years, the prevalence of obesity decreased 40%, from 13.9% to 8.4%.[11] Another analysis of NHANES data showed that among youth aged 2 to 19 years, the prevalence of severe obesity was not statistically significantly different between 2009 to 2010 and 2011 to 2012.[14]

Adults

- According to NHANES data, there have been no overall changes in obesity prevalence in adults between 2003 to 2004[17] and 2011 to 2012,[11] although among women aged ≥60 years, the prevalence of obesity increased from 31.5% in 2003 to 2004 to 38.1% in 2011 to 2012.[11]
- Another study reported that for women, but not men, the increase in waist circumference from NHANES 1999 to 2000 to NHANES 2010 to 2011 was greater than expected based on the increase in BMI.[18]

Morbidity

Youth

- According to the National Longitudinal Study of Adolescent Health, compared with those with normal weight or those who were overweight, obese adolescents had a 16-fold increased risk of having severe obesity (BMI ≥40 kg/m^2) as adults, and 70.5% of adolescents with severe obesity maintained this weight status into adulthood.[19]
- Overweight and obese children and adolescents are at increased risk for future adverse health effects, including the following[20]:
  - —Increased prevalence of traditional cardiovascular risk factors such as hypertension, hyperlipidemia, and DM. Despite these risks, a recent article examined 2 decades of data from 1974 to 1993. Although the prevalence of obesity among children increased during this time period, hypertension did not.[21]
  - —Poor school performance, tobacco use, alcohol use, premature sexual behavior, and poor diet

—Other associated health conditions, such as asthma, hepatic steatosis, sleep apnea, stroke, some cancers (breast, colon, and kidney), renal insufficiency, musculoskeletal disorders, and gallbladder disease

- Data from 4 Finnish cohort studies examining childhood and adult BMI with a mean follow-up of 23 years found that overweight or obese children who were obese in adulthood had increased risks of type 2 DM, hypertension, dyslipidemia, and carotid atherosclerosis, whereas those who achieved normal weight by adulthood had risks comparable to individuals who were never obese.[22]
- The CARDIA study showed that young adults who were overweight or obese had lower health-related quality of life than normal-weight participants 20 years later.[23]

Adults

- Using data from NHANES 2007 to 2010, the prevalences of DM, hypertension, and dyslipidemia were highest for obese, then overweight, then normal-weight adults, specifically, 18.5%, 8.2%, and 5.4% for DM, 35.7%, 26.4%, and 19.8% for hypertension, and 49.7%, 44.2%, and 28.6% for dyslipidemia.[24]
- Analyses of continuous BMI across the entire BMI range show that the greater the BMI, the higher the risk for type 2 DM.[25]
- Among 68 070 participants across multiple NHANES surveys, the decline in BP in recent birth cohorts is slowing, mediated by BMI.[26]
- Cardiovascular risks may be even higher with severe obesity (class III, BMI ≥40 kg/m^2) than with class I or class II obesity.[27] Among 156 775 postmenopausal women in the WHI, for severe obesity versus normal BMI, HRs (95% CIs) for mortality were 1.97 (1.77–2.20) in white women, 1.55 (1.20–2.00) in African American women, and 2.59 (1.55–4.31) in Hispanic women; for CHD, HRs were 2.05 (1.80–2.35), 2.24 (1.57–3.19), and 2.95 (1.60–5.41), respectively; and for CHF, HRs were 5.01 (4.33–5.80), 3.60 (2.30–5.62), and 6.05 (2.49–14.69), respectively. However, CHD risk was strongly related to CVD risk factors across BMI categories, even in severe obesity, and CHD incidence was similar by race/ethnicity when adjusted for differences in BMI and CVD risk factors.[27]
- In a meta-analysis from 58 cohorts, representing 221 934 people in 17 developed countries with 14 297 incident CVD outcomes, BMI, waist circumference, and waist-to-hip ratio were strongly associated with intermediate risk factors of DM, higher SBP and TC, and lower HDL-C. The strong associations of adiposity measures (BMI, waist circumference, waist-to-hip ratio) with CVD outcomes were almost completely accounted for by adjusting for these intermediate risk factors (DM, SBP, TC and HDL-C), along with age, sex, and smoking status, resulting in minimal associations of the adiposity measures with CVD outcomes after adjustment. Measures of adiposity also did not improve risk discrimination or reclassification when data on intermediate risk factors were included.[28]
- The MESA study found that obesity is associated with subclinical atherosclerosis, including CAC and carotid IMT, and this association persists after adjustment for CVD risk factors.[29]
- Obesity is also a strong predictor of sleep-disordered breathing, itself strongly associated with the development of CVD, as well as with myriad other health conditions, including numerous cancers, nonalcoholic fatty liver disease, gallbladder disease, musculoskeletal disorders, and reproductive abnormalities.[30] A systematic review of prospective studies examining overweight and obesity as predictors of major stroke subtypes in >2 million participants over ≥4 years found an adjusted RR for ischemic stroke of 1.22 (95% CI, 1.05–1.41) in overweight individuals and an RR of 1.64 (95% CI, 1.36–1.99) for obese individuals relative to normal-weight individuals. RRs for hemorrhagic stroke were 1.01 (95% CI, 0.88–1.17) and 1.24 (95% CI, 0.99–1.54) for overweight and obese individuals, respectively. These risks were graded with increasing BMI and were independent of age, lifestyle, and other cardiovascular risk factors.[31]
- A recent report from ARIC showed that VTE risk over 15.5 years (237 375 person-years) was associated with higher BMI (and current smoking) but not with other CVD risk factors.[4]
- A recent meta-analysis of 15 prospective studies demonstrated the increased risk for Alzheimer disease or vascular dementia and any dementia was 1.35 and 1.26 for overweight, respectively, and 2.04 and 1.64 for obesity, respectively.[32] The inclusion of obesity in dementia forecast models increases the estimated prevalence of dementia through 2050 by 9% in the United States and 19% in China.[33]
- Ten-year follow-up data from the SOS intervention study indicated that to maintain a favorable effect on cardiovascular risk factors, more than the short-term goal of 5% weight loss is needed to overcome secular trends and aging effects.[34]
- A clinical trial of 130 severely obese adults randomized to either 12 months of diet and PA or only 6 months of PA resulted in 12.1 and 9.9 kg, respectively, of weight loss at 1 year, with improvements in waist circumference, visceral fat, BP, and insulin resistance.[35]
- A BMI paradox has been reported, with higher-BMI patients demonstrating favorable outcomes in CHF, hypertension, peripheral vascular disease, and CAD; similar findings have been seen for percent body fat. In AFFIRM, a multicenter trial of AF, obese patients had lower all-cause mortality (HR, 0.77; P=0.01) than normal-weight patients after multivariable adjustment over a 3-year follow-up period.[36]
- Interestingly, among 2625 participants with new-onset DM, rates of total, CVD, and non-CVD mortality were higher among normal-weight people than overweight/obese participants, with adjusted HRs of 2.08 (95% CI, 1.52–2.85), 1.52 (95% CI, 0.89–2.58), and 2.32 (95% CI, 1.55–3.48), respectively.[37]

Mortality

- Childhood BMIs in the highest quartile were associated with premature death as an adult in a cohort of 4857 American Indian children during a median follow-up of 23.9 years.[38]
- According to NHIS data, among young adults aged 18 to 39 years, the HR for all-cause mortality was 1.07 (95%

CI, 0.91–1.26) for self-reported overweight (not including obese) individuals, 1.41 (95% CI, 1.16–1.73) for obese individuals, and 2.46 for extremely obese individuals (95% CI, 1.91–3.16).[39]

- Among adults, obesity was associated with nearly 112 000 excess deaths (95% CI, 53 754–170 064) relative to normal weight in 2000. Class I obesity (BMI 30 to <35 kg/m^2) was associated with almost 30 000 of these excess deaths (95% CI, 8534–68 220) and classes II to III obesity (BMI ≥35 kg/m^2) with >82 000 (95% CI, 44 843–119 289). Underweight was associated with nearly 34 000 excess deaths (95% CI, 15 726–51 766). As other studies have found,[40] being overweight but not obese (BMI 25 to <30 kg/m^2) was not associated with excess deaths.[41]
- A recent systematic review (2.88 million individuals and >270 000 deaths) showed that relative to normal BMI (18.5 to <25 kg/m^2), all-cause mortality was lower for overweight but not obese individuals (HR, 0.94; 95% CI, 0.91–0.96) and was not elevated for grade 1 obesity (HR, 0.95; 95% CI, 0.88–1.01). All-cause mortality was higher for obesity (all grades combined; HR, 1.18; 95% CI, 1.12–1.25) and for grades 2 and 3 obesity (HR, 1.29; 95% CI, 1.18–1.41).[42]
- In a collaborative analysis of data from almost 900 000 adults in 57 prospective studies, mostly in western Europe and North America, overall mortality was lowest at a BMI of ≈22.5 to 25 kg/m^2 in both sexes and at all ages, after exclusion of early follow-up and adjustment for smoking status. Above this range, each 5-kg/m^2-higher BMI was associated with ≈30% higher all-cause mortality, and no specific cause of death was inversely associated with BMI. Below 22.5 to 25 kg/m^2, the overall inverse association with BMI was predominantly related to strong inverse associations for smoking-related respiratory disease, and the only clearly positive association was for ischemic heart disease.[43]
- In a meta-analysis of 1.46 million white adults, over a mean follow-up period of 10 years, all-cause mortality was lowest at BMI levels of 20.0 to 24.9 kg/m^2. Among women, compared with a BMI of 22.5 to 24.9 kg/m^2, the HRs for death were as follows: BMI 15.0 to 18.4 kg/m^2, 1.47; 18.5 to 19.9 kg/m^2, 1.14; 20.0 to 22.4 kg/m^2, 1.0; 25.0 to 29.9 kg/m^2, 1.13; 30.0 to 34.9 kg/m^2, 1.44; 35.0 to 39.9 kg/m^2, 1.88; and 40.0 to 49.9 kg/m^2, 2.51. Similar estimates were observed in men.[44]
- According to data from the NCDR, among patients presenting with STEMI and a BMI ≥40 kg/m^2, in-hospital mortality rates were higher for patients with class III obesity (OR, 1.64; 95% CI, 1.32–2.03) when class I obesity was used as the referent.[45]
- Overweight was associated with significantly increased mortality resulting from DM or kidney disease and was not associated with increased mortality resulting from cancer or CVD in an analysis of 2004 data from NHANES. Obesity was associated with significantly increased mortality caused by CVD, some cancers, and DM or kidney disease. Obesity was associated with 13% of CVD deaths in 2004.[46]
- Based on a comparison of data from 1980 and 2000, reductions in smoking, cholesterol, BP, and physical inactivity levels resulted in estimated gains of 2 770 500 life-years but with a loss of 715 000 life-years caused by the increased prevalence of obesity and DM.[47]
- In a study of 22 203 women and men from England and Scotland, metabolically unhealthy obese individuals were at an increased risk of all-cause mortality compared with metabolically healthy obese individuals (HR, 1.72; 95% CI, 1.23–2.41).[48]
- In a comparison of 5 different anthropometric variables (BMI, waist circumference, hip circumference, waist-to-hip ratio, and waist-to-height ratio) in 62 223 individuals from Norway with 12 years of follow-up from the HUNT 2 study, the risk of death per SD increase in each measure was 1.02 (95% CI, 0.99–1.06) for BMI, 1.10 (95% CI, 1.06–1.14) for waist circumference, 1.01 (95% CI, 0.97–1.05) for hip circumference, 1.15 (95% CI, 1.11–1.19) for waist-to-hip ratio, and 1.12 (95% CI, 1.08–1.16) for waist-to-height ratio. For CVD mortality, the risk of death per SD increase was 1.12 (95% CI, 1.06–1.20) for BMI, 1.19 (95% CI, 1.12–1.26) for waist circumference, 1.06 (95% CI, 1.00–1.13) for hip circumference, 1.23 (95% CI, 1.16–1.30) for waist-to-hip ratio, and 1.24 (95% CI, 1.16–1.31) for waist-to-height ratio.[49] However, because BMI and waist circumference are strongly correlated, large samples are needed to evaluate their independent contributions to risk.[10,50] A recent pooled analysis of waist circumference and mortality in 650 386 adults followed up for a median of 9 years revealed that a 5-cm increment in waist circumference was associated with an increase in all-cause mortality at all BMI categories examined from 20 to 50 kg/m^2.[51] Similarly, in an analysis of postmenopausal women in the WHI limited to those with BMI ≥40 kg/m^2, mortality, CHD, and CHF incidence all increased with waist circumference >115 and >122 cm compared with ≤108.4 cm.[27] Finally, among 14 941 men and women in ARIC, the risk of sudden cardiac death was associated with higher BMI and waist circumference, with traditional risk factors mediating the association with BMI but not with waist circumference.[52]

Cost

- Obesity costs the healthcare system, healthcare payers, and obese individuals themselves.
- In 2008 US dollars, the estimated annual medical cost of obesity was $147 billion; the medical costs for those who were obese were $1429 higher than for those at normal weight.[53] A more recent study estimated mean annual per capita healthcare expenses of obesity were $1160 for men and $1525 for women.[54]
- According to NHANES I data linked to Medicare and mortality records, obese 45-year-olds had lifetime Medicare costs of $163 000 compared with $117 000 among those with normal weight by the time they reached 65 years of age.[55]
- In the absence of obesity, annual medical expenditures would be 6.7% (based on 2006 MEPS data) to 10.7% (based on 2006 BRFSS data) lower.[56]
- According to data from the Medicare Current Beneficiary Survey from 1997 to 2006, in 1997, expenditures for a Part A and Part B services beneficiary were $6832 for a normal-weight person, which was more than for overweight ($5473) or obese ($5790) individuals. However, over time, expenses increased more rapidly for overweight and obese individuals.[57]

- The costs of obesity are high: Obese people pay on average $1429 (42%) more for healthcare costs than normal-weight individuals. For obese beneficiaries, Medicare pays $1723 more, Medicaid pays $1021 more and private insurers pay $1140 more than for beneficiaries who are at normal weight. Similarly, obese people have 46% higher inpatient costs and 27% more outpatient visits and spend 80% more on prescription drugs.[53]
- The total excess cost related to the current prevalence of adolescent overweight and obesity is estimated to be $254 billion ($208 billion in lost productivity secondary to premature morbidity and mortality and $46 billion in direct medical costs).[58]
- A recent study recommended the use of $19 000 as the incremental lifetime medical cost of an obese child relative to a normal-weight child who maintains normal weight throughout adulthood.[59]

Bariatric Surgery

- Lifestyle interventions often do not provide sustained significant weight loss for people who are obese. For obese people with or at risk for comorbidities, bariatric surgery may be an option. Bariatric surgery has short-term risks; other adverse effects may only be identified during postsurgery follow-up. The evidence is strong that among obese adults, bariatric surgery produces greater weight loss and maintenance of lost weight than lifestyle intervention, with some variations depending on the type of procedure and the patient's initial weight.[25]
- Patients with BMI >40 kg/m^2 or >35 kg/m^2 with an obesity-related comorbidity are eligible for gastric bypass surgery, which is typically performed as an RYGB, vertical sleeve gastrectomy, adjustable gastric banding, or biliopancreatic diversion with duodenal switch.[60]
- In a large bariatric surgery cohort, the prevalence of high 10-year predicted CVD risk was 36.5%,[61] but 76% of those with low 10-year risk had high lifetime predicted CVD risk. The corresponding prevalence in US adults is 18% and 56%, respectively.[62]
- Benefits reported for bariatric surgery include substantial weight loss; remission of DM, hypertension, and dyslipidemia; reduced incidence of mortality; and fewer CVD events. Reported risks with bariatric surgery include not only perioperative mortality and adverse events but also weight regain, DM recurrence (particularly for those with longer DM duration before surgery), bone loss, increases in substance use disorders, suicide, and nutritional deficiencies. Outcomes appear to vary by bariatric surgery technique. Outcomes must be assessed cautiously, because most bariatric surgery data come from nonrandomized observational studies, with only a few randomized clinical trials comparing bariatric surgery to medical treatment for patients with DM. Furthermore, studies do not always report their definition of "remission" or "partial remission" for comorbidities such as DM, hypertension, and dyslipidemia.
- A recent meta-analysis reported postsurgery percent remission separately for randomized clinical trials and observational studies as follows: for DM remission, ≈92% (randomized clinical trials) and 86% (observational studies); for hypertension remission, 75% (randomized clinical trials) and 74% (observational studies); and for dyslipidemia remission, 76% (randomized clinical trials) and 68% (observational studies). Overall percentage of excess weight loss was ≈60% (randomized clinical trials) and 46% (observational studies) at 1 year and ≈42% (randomized clinical trials) and 62% (observational studies) at 5 years. However, the percentage of excess weight loss was greater with gastric bypass (63%–72%) than with sleeve gastrectomy (51%–79%) or adjustable gastric banding (33%–34%) at 1 year but more similar for observational data at 3 years, that is, 76% for gastric bypass versus ≈59% for adjustable gastric banding or sleeve gastrectomy. Postsurgery mortality was low, but complication rates were ≈17% (randomized clinical trials) and 10% (observational studies), higher for gastric bypass, and reoperation rates were ≈7% (randomized clinical trials) and 6% (observational studies), higher for adjustable gastric banding than for gastric bypass or sleeve gastrectomy.[63]
- A meta-analysis of RCTs also showed substantially higher weight loss and DM remission for bariatric surgery than for conventional medical therapy, with follow-up ≤2 years.[64]
- With 3-year follow-up, a randomized clinical trial among obese patients with uncontrolled type 2 DM reported 38%, 24%, and 5% of patients in the gastric bypass, sleeve gastrectomy, and medical therapy group, respectively, had HbA_{1c} ≤6.0%.[65] At 3-year follow-up in the LABS study, 67.5% (RYGB) and 28.6% (laparoscopic adjustable gastric banding) of patients had partial remission of DM. Dyslipidemia resolved in 62% (RYGB) and 27% (laparoscopic adjustable gastric banding); remission of hypertension occurred in 38% (RYGB) and 17.4% (laparoscopic adjustable gastric banding).[66]
- Long-term follow-up data are scarce, but in the SOS study, remission of DM at 2 years was 72% for the surgical group and 16% in the matched control group but decreased in both groups at 10 and 15 years while remaining higher in the surgical group (38% at 10 years and 30% at 15 years for the surgical group).[67]
- Another meta-analysis of observational cohort studies showed a reduced risk of mortality (OR, 0.48; 95% CI, 0.35–0.64), CVD (OR, 0.54; 95% CI, 0.41–0.70), MI (OR, 0.46; 95% CI, 0.30–0.69), and stroke (OR, 0.49; 95% CI, 0.32–0.75), but RCT data are lacking.[68]
- According to retrospective data from the United States, among 9949 patients who underwent gastric bypass surgery, after a mean of 7 years, long-term mortality was 40% lower among the surgically treated patients than among obese control subjects. Specifically, cancer mortality was reduced by 60%, DM mortality by 92%, and CAD mortality by 56%. Nondisease death rates (eg, accidents, suicide) were 58% higher in the surgery group.[69]
- A recent retrospective cohort from the Veterans Affairs medical system showed that in a propensity-matched analysis, bariatric surgery was not associated with reduced mortality compared with obese control subjects (time-adjusted HR, 0.94; 95% CI, 0.64–1.39).[70] However, further analysis of that cohort showed that a reduced mortality risk was observed during 5 to 14 years of follow-up.[71]

- Adolescents (10–19 years old) underwent bariatric surgery at a rate of 0.8/100 000 procedures in 2000, which increased to 2.3/100 000 in 2003 and remained constant by 2009 at 2.4/100 000.[72] The Teen-LABS study recently reported a favorable short-term (30 day) complications profile of bariatric surgery among 242 patients aged 13 to 19 years.[73]
- According to the 2006 NHDS, the incidence of bariatric surgery was estimated at 113 000 cases per year, with costs of nearly $1.5 billion annually.[74]
- A recent cost-effectiveness study of laparoscopic adjustable gastric banding showed that after 5 years, $4970 was saved in medical expenses; if indirect costs were included (absenteeism and presenteeism), savings increased to $6180 and $10 960, respectively.[75] However, when expressed per quality-adjusted life expectancy, only $6600 was gained for laparoscopic gastric bypass, $6200 for laparoscopic adjustable gastric band, and $17 300 for open RYGB, none of which exceeded the standard $50 000 per quality-adjusted life expectancy gained.[76] Two other recent large studies failed to demonstrate a cost benefit for bariatric surgery versus matched patients over 6 years of follow-up.[77,78] However, another study showed cost savings for bariatric surgery among patients with DM at baseline.[79]

Global Burden of High BMI and Obesity

- Although there is considerable variability in overweight and obesity data methodology and quality worldwide, cross-country comparison can help reveal different patterns. Worldwide, between 1980 and 2013, the proportion of overweight or obese adults increased from 28.8% (95% UI, 28.4%–29.3%) to 36.9% (95% UI, 36.3%–37.4%) among men and from 29.8% (95% UI, 29.3%–30.2%) to 38.0% (95% UI, 37.5%–38.5%) among women. Since 2006, the increase in adult obesity in developed countries has slowed. For children and adolescents, the prevalence of overweight and obesity in 2013 in developed countries was 23.8% (95% UI, 22.9%–24.7%) of boys and 22.6% (95% UI, 21.7%–23.6%) of girls, and in developing countries, ranged from 8.1% (95% UI, 7.7%–8.6%) to 12.9% (95% UI, 12.3%–13.5%) in 2013 for boys and from 8.4% (95% UI, 8.1%–8.8%) to 13.4% (95% UI, 13.0%–13.9%) in girls. The estimated prevalence of adult obesity exceeded 50% of men in Tonga and women in Kuwait, Kiribati, the Federated States of Micronesia, Libya, Qatar, Tonga, and Samoa. As of 2013, around the world, obesity rates are higher for women than men and in developed countries than in developing countries. Higher obesity rates for women versus men occur for age ≥45 years in developed countries but at age ≥25 years in developing countries.[80]
- Between 1980 and 2008, mean BMI increased worldwide by 0.4 kg/m^2 per decade for men and 0.5 kg/m^2 per decade for women, with trends varying between nations. In 2008, an estimated 1.46 billion adults were overweight or obese. The prevalence of obesity was estimated at 205 million men and 297 million women. The highest prevalence of male obesity is in the United States, Southern and Central Latin America, Australasia, and Central and Western Europe, and the lowest prevalence is in South and Southeast Asia and East, Central, and West Africa. For women, the highest prevalence of obesity is in Southern and North Africa, the Middle East, Central and Southern Latin America, and the United States, and the lowest is in South, East, and Southeast Asia; the high-income Asia-Pacific subregion; and East, Central, and West Africa.[81]
- Between 1990 and 2010, estimated worldwide deaths attributable to high BMI increased 1.7-fold, from 1 963 549 to 3 371 232, and DALYs lost because of high BMI rose 1.8-fold, from 51 565 to 93 609. Therefore, between 1990 and 2010, high BMI went from tenth to sixth in ranking of contribution to the global burden of disease and was among the top 5 risk factors for global burden of disease in all regions except high-income Asia-Pacific; East, Southeast, and South Asia; and East, Central, and West sub-Saharan Africa.[82]

Table 6-1. Overweight and Obesity

	Prevalence of Overweight and Obesity, 2009–2012, Age >20 y	Prevalence of Obesity, 2009–2012, Age >20 y	Prevalence of Overweight and Obesity 2011–2012, Ages 2–19 y	Prevalence of Obesity, 2011–2012, Ages 2–19 y	Cost, 2008*
Both sexes, n (%)	159 200 000 (68.5)	81 800 000 (35.2)	23 700 000 (31.8)	12 600 000 (16.9)	$147 Billion
Males	81 500 000 (72.5)	38 600 000 (34.4)	12 200 000 (32.0)	6 300 000 (16.7)	…
Females	77 700 000 (64.7)	43 200 000 (36.0)	11 500 000 (31.6)	6 300 000 (17.2)	…
NH white males, %	72.7	34.2	27.8	12.6	…
NH white females, %	61.2	32.5	29.2	15.6	…
NH black males, %	69.4	37.9	34.4	19.9	…
NH black females, %	81.9	57.5	36.1	20.5	…
Hispanic males, %	80.1	38.4	40.7	24.1	…
Hispanic females, %	76.3	42.9	37.0	20.6	…

Overweight and obesity in adults is defined as body mass index (BMI) ≥25 kg/m^2. Obesity in adults is defined as BMI ≥30 kg/m^2. In children, overweight and obesity are based on BMI-for-age values at or above the 85th percentile of the 2000 Centers for Disease Control and Prevention (CDC) growth charts. In children, obesity is based on BMI-for-age values at or above the 95th percentile of the CDC growth charts. In January 2007, the American Medical Association's Expert Task Force on Childhood Obesity recommended new definitions for overweight and obesity in children and adolescents[83]; however, statistics based on this new definition are not yet available.

Ellipses (…) indicate data not available; and NH, non-Hispanic.

*Data from Finkelstein et al.[75]

Sources: National Health and Nutrition Examination Survey (NHANES) 2009 to 2012 (adults), unpublished National Heart, Lung, and Blood Institute (NHLBI) tabulation; NHANES 2011 to 2012 (ages 2–19 years) from Ogden et al.[11] Extrapolation for ages 2 to 19 years from NHLBI tabulation of US Census resident population on July 1, 2012.

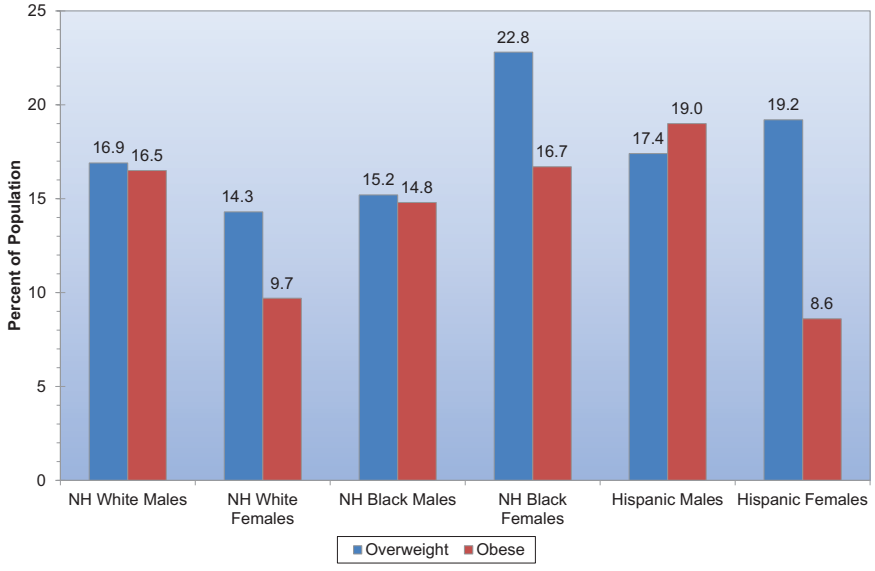

Chart 6-1. Prevalence of overweight and obesity among students in grades 9 through 12 by sex and race/ethnicity. NH indicates non-Hispanic. Data derived from Kann et al (Table 101).[84]

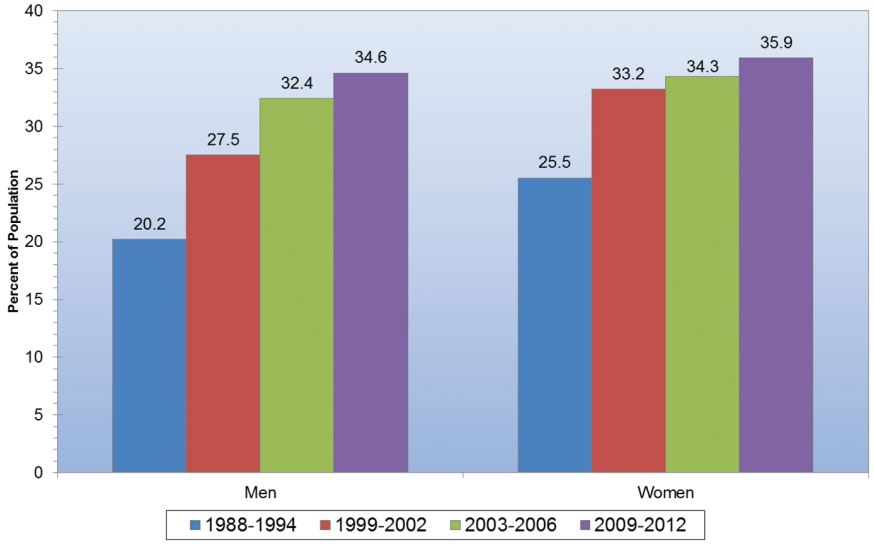

Chart 6-2. Age-adjusted prevalence of obesity in adults 20 to 74 years of age by sex and survey year (National Health and Nutrition Examination Survey: 1988–1994, 1999–2002, 2003–2006, and 2009–2012). Obesity is defined as body mass index of 30.0 kg/m^2. Data derived from *Health, United States, 2014* (National Center for Health Statistics).[85]

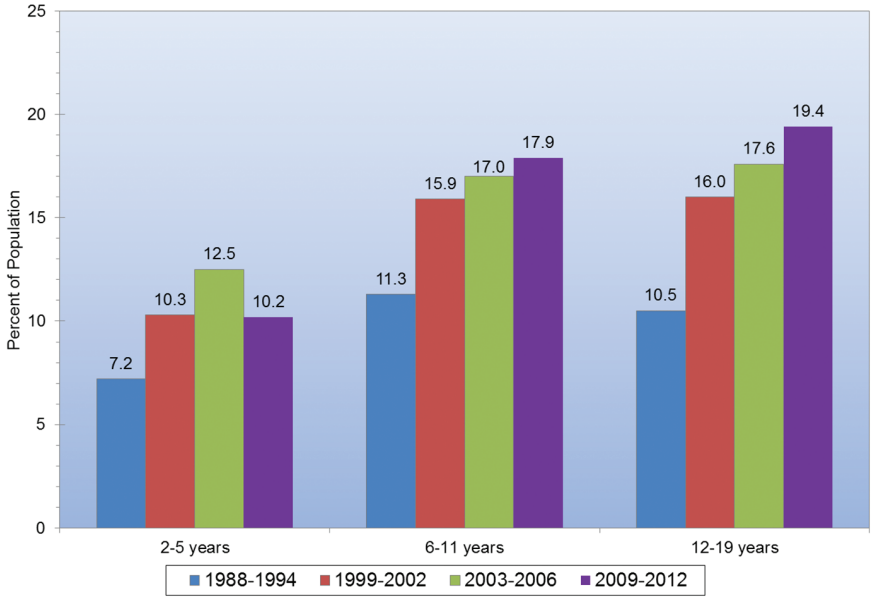

Chart 6-3. Trends in the prevalence of obesity among US children and adolescents by age and survey year (National Health and Nutrition Examination Survey: 1988–1994, 1999–2002, 2003–2006, 2009–2012). Data derived from *Health, United States, 2014* (National Center for Health Statistics).[85]

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7. Family History and Genetics

See Tables 7-1 through 7-3.

Biologically related first-degree relatives (siblings, offspring, and parents) share roughly 50% of their genetic variation with one another. This constitutes much greater sharing of genetic variation than with a randomly selected person from the population, and thus, familial aggregation of traits lends support for a genetic basis for the trait. Similarly, racial/ethnic minorities are more likely to share their genetic variation within their demographic than with other demographics. Familial aggregation of CVD may be related to aggregation of specific behaviors (eg, smoking, alcohol use) or risk factors (eg, hypertension, DM, obesity) that may themselves have environmental and genetic contributors. Unlike classic mendelian genetic risk factors, whereby usually 1 mutation directly causes 1 disease, a complex trait's genetic contributors may increase risk without necessarily always causing the condition. The effect size of any specific contributor to risk may be small but widespread throughout a population, or it may be large but affect only a small population, or it may have an enhanced risk when an environmental contributor is present. We present a summary of evidence that a genetic risk for CVD is likely, as well as a summary of evidence on the most consistently replicated genetic markers for CHD and stroke identified to date. A comprehensive scientific statement on the role of genetics and genomics for the prevention and treatment of CVD is available elsewhere.[1]

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Abbreviations Used in Chapter 7

AAA	abdominal aortic aneurysm
ABI	ankle-brachial index
ACS	acute coronary syndrome
AF	atrial fibrillation
BMI	body mass index
CAC	coronary artery calcification
CAD	coronary artery disease
CARDIoGRAMplusC4D	Coronary Artery Disease Genome-wide Replication and Meta-Analysis (CARDIOGRAM) plus the Coronary Artery Disease (C4D) Genetics Consortium
CHD	coronary heart disease
CI	confidence interval
CRP	C-reactive protein
CVD	cardiovascular disease
DBP	diastolic blood pressure
DM	diabetes mellitus
FHS	Framingham Heart Study
GFR	glomerular filtration rate
HbA_{1c}	hemoglobin A_{1c} (glycosylated hemoglobin)
HD	heart disease
HDL-C	high-density lipoprotein cholesterol
HF	heart failure
HR	hazard ratio
LDL-C	low-density lipoprotein cholesterol
MI	myocardial infarction
NHANES	National Health and Nutrition Examination Survey
NHLBI	National Heart, Lung, and Blood Institute
OR	odds ratio
PAD	peripheral artery disease
SBP	systolic blood pressure
SE	standard error
SNP	single-nucleotide polymorphism
VTE	venous thromboembolism

Family History

Prevalence

- Among adults ≥20 years of age, 12.0% (SE 0.4%) reported having a parent or sibling with a heart attack or angina before the age of 50 years. The racial/ethnic breakdown is as follows (NHANES 2009–2012, unpublished NHLBI tabulation):
  - —For non-Hispanic whites, 11.5% (SE 0.6%) for men, 14.6% (SE 0.8%) for women
  - —For non-Hispanic blacks, 9.1% (SE 0.8%) for men, 12.3% (SE 0.7%) for women
  - —For Hispanics, 7.6% (SE 0.7%) for men, 10.1% (SE 1.0%) for women
- HD occurs as people age, so the prevalence of family history will vary depending on the age at which it is assessed. The breakdown of reported family history of heart attack by age of survey respondent in the US population as measured by NHANES is as follows (NHANES 2009–2012, unpublished NHLBI tabulation):
  - —Age 20 to 39 years, 8.0% (SE 0.6%) for men, 9.7% (SE 0.8%) for women
  - —Age 40 to 59 years, 12.1% (SE 0.8%) for men, 15.2% (SE 1.4%) for women
  - —Age 60 to 79 years, 13.3% (SE 1.5%) for men, 16.6% (SE 1.3%) for women
  - —Age ≥80 years, 8.7% (SE 1.9%) for men, 15.5% (SE 2.4%) for women

In the multigenerational FHS, only 75% of participants with a documented parental history of a heart attack before age 55 years reported that history when asked.[2]

Impact of Family History

Coronary Heart Disease

- Paternal history of premature heart attack has been shown to approximately double the risk of a heart attack in men and increase the risk in women by ≈70%.[3,4]
- History of a heart attack in both parents increases the risk of heart attack, especially when 1 parent had a premature heart attack[5] (Table 7-1).
- Sibling history of CVD has been shown to increase the odds of CVD in men and women by 45% (OR, 1.45; 95% CI, 1.19–1.91) in models accounting for CVD risk factors.[6]

- Family history of premature angina, MI, angioplasty, or bypass surgery increased the lifetime risk by ≈50% for both HD (from 8.9% to 13.7%) and CVD (from 14.1% to 21%) mortality.[7]
- In a recent international study of individuals with premature ACS (age ≤55 years), more women (28%) than men (20%) had a family history of CAD (P=0.008). However, compared with patients without a family history, patients with a family history of CAD had a higher prevalence of traditional CVD risk factors, including dyslipidemia and obesity. Women with a family history had a higher prevalence of each traditional risk factor (obesity, DM, dyslipidemia, and hypertension) except smoking.[8]

Other CVDs

- A parental history of AF was associated with ≈80% increased odds of AF in men and women.[9] The risk of AF was increased the younger the age of onset and the more family members affected.[10] In a Swedish study,[11] the odds of AF associated with familial AF (OR, 5.04; 95% CI, 4.26–5.82) were higher in people with a history of premature AF (diagnosed AF at age <50 years). Interestingly, there was modest spousal aggregation of AF, consistent with a contribution of shared environment to AF risk; the spousal OR for AF was 1.16 (95% CI, 1.13–1.19).[11]
- A history of stroke in a first-degree relative increases the odds of stroke in men and women by ≈50%.[12]
- A parental history of HF also is associated with an increased odds of offspring HF (multivariable-adjusted HR, 1.7; 95% CI, 1.11–2.60).[13]
- In a Swedish population-based case-control study, the risk of thoracic aortic disease increased the greater the number of affected relatives and the younger the individual affected. The OR was 5.8 (95% CI, 4.3–7.7) with 1 affected relative versus 20 (95% CI, 2.2–179) with at least 2 affected relatives.[14]
- Similarly, the odds of having PAD were elevated (OR, 1.83; 95% CI, 1.03–3.26) in individuals with a family history of PAD.[15]
- A family history of VTE is associated with 2- to 3-fold odds of VTE, irrespective of identified known predisposing genetic factors.[16,17]

Genetics

Heart Disease

- Genome-wide association is a robust technique to identify associations between genotypes and phenotypes. Table 7-2 presents results from the CARDIoGRAMplusC4D Consortium, which represents the largest genetic study of CAD to date. Although the ORs are modest, ranging from 1.06 to 1.51 per copy of the risk allele (individuals may harbor up to 2 copies of a risk allele), these are common alleles, which suggests that the attributable risk may be substantial. Additional analysis suggested that loci associated with CAD were involved in lipid metabolism and inflammation pathways.[18]
- The relationship between genetic variants associated with CHD and measured CHD risk factors is complex, with some genetic markers associated with multiple risk factors and other markers showing no association with risk factors.[19]
- Genetic markers discovered thus far have not been shown to add to cardiovascular risk prediction tools beyond current models that incorporate family history.[20] Genetic markers also have not been shown to improve prediction of subclinical atherosclerosis beyond traditional risk factors.[21] However, an association between genetic markers and CAC has been seen.[22]
- The most consistently replicated genetic marker for HD in European-derived populations is located at 9p21.3. At this single-nucleotide polymorphism, ≈27% of the white population is estimated to have 0 risk alleles, 50% is estimated to have 1 risk allele, and the remaining 23% is estimated to have 2 risk alleles.[23] In meta-analyses of individuals of East Asian ancestry, variants at 9p21.3 have also been reported to be associated with CHD (OR per risk allele, 1.3; 95% CI, 1.25–1.35).[24]
- The 10-year HD risk for a 65-year-old man with 2 risk alleles at 9p21.3 and no other traditional risk factors is ≈13.2%, whereas a similar man with 0 alleles would have a 10-year risk of ≈9.2%. The 10-year HD risk for a 40-year-old woman with 2 alleles and no other traditional risk factors is ≈2.4%, whereas a similar woman with 0 alleles would have a 10-year risk of ≈1.7%.[23]
- Variation at the 9p21.3 region also is associated with an increased risk of HF[25] and sudden death.[26] Associations have also been observed between the 9p21.3 region and CAC.[27,28] Additionally, stronger associations have been found between variation at 9p21.3 and earlier[27,28] and more severe[29] heart attacks. Paradoxically, a recent meta-analysis reported that variants at 9p21.3 were associated with incident (HR, 1.19; 95% CI, 1.17–1.22) but not recurrent (HR, 1.01; 95% CI, 0.97–1.06) CHD events,[30] which supports the genetic complexity of CHD. The biological mechanisms underpinning the association of genetic variation in the 9p21 region with disease outcomes are still under investigation.

Stroke

- The same 9p21.3 region has also been associated with intracranial aneurysm,[31] AAA,[32] and ischemic stroke.[33]
- For large-vessel ischemic stroke, an association for large-vessel stroke with histone deacetylase 9 on chromosome 7p21.1 has been identified (>9 000 subjects) and replicated (>12 000 subjects).[33,34]

CVD Risk Factors

- Heritability is the ratio of genetically caused variation to the total variation of a trait or measure. Table 7-3 presents heritability estimates for standard CVD risk factors using data generated from the FHS. These data suggest that most CVD risk factors have at least moderate heritability.

Table 7-1. OR for Combinations of Parental Heart Attack History

	OR (95% CI)
No family history	1.00
One parent with heart attack ≥50 y of age	1.67 (1.55–1.81)
One parent with heart attack <50 y of age	2.36 (1.89–2.95)
Both parents with heart attack ≥50 y of age	2.90 (2.30–3.66)
Both parents with heart attack, one <50 y of age	3.26 (1.72–6.18)
Both parents with heart attack, both <50 y of age	6.56 (1.39–30.95)

CI indicates confidence interval; and OR, odds ratio.
Data derived from Chow et al.[5]

Table 7-2. Validated SNPs for CAD, the Nearest Gene, and the OR From the CARDIoGRAMplusC4D Consortium

SNP	Chromosome	Gene	Effect Size (OR)	Effect Allele Frequency
rs602633	1	*SORT1*	1.12	0.77
rs17464857	1	*MIA3*	1.05	0.87
rs17114036	1	*PPAP2B*	1.11	0.91
rs11206510	1	*PCSK9*	1.06	0.84
rs4845625	1	*IL6R*	1.04	0.47
rs6725887	2	*WDR12*	1.12	0.11
rs515135	2	*APOB*	1.08	0.82
rs2252641	2	*ZEB2-AC074093.1*	1.04	0.46
rs1561198	2	*VAMP5-VAMP8-GGCX*	1.05	0.45
rs6544713	2	*ABCG5-ABCG8*	1.06	0.30
rs9818870	3	*MRAS*	1.07	0.14
rs7692387	4	*GUCY1A3*	1.06	0.81
rs1878406	4	*EDNRA*	1.06	0.15
rs273909	5	*SLC22A4-SLC22A5*	1.09	0.14
rs12205331	6	*ANKS1A*	1.04	0.81
rs9369640	6	*PHACTR1*	1.09	0.65
rs12190287	6	*TCF21*	1.07	0.59
rs3798220	6	*LPA*	1.28	0.01
rs10947789	6	*KCNK5*	1.06	0.76
rs4252120	6	*PLG*	1.06	0.73
rs11556924	7	*ZC3HC1*	1.08	0.65
rs12539895	7	*7q22*	1.08	0.19
rs2023938	7	*HDAC9*	1.07	0.10
rs264	8	*LPL*	1.05	0.86
rs2954029	8	*TRIB1*	1.04	0.55
rs1333049	9	*CDKN2A, CDKN2B*	1.23	0.47
rs579459	9	*ABO*	1.07	0.21
rs2505083	10	*KIAA1462*	1.06	0.42
rs501120	10	*CXCL12*	1.07	0.83
rs12413409	10	*CYP17A1-CNNM2-NT5C2*	1.10	0.89
rs2246833	10	*LIPA*	1.06	0.38
rs9326246	11	*ZNF259-APOA5-A4-C3-A1*	1.09	0.10
rs974819	11	*PDGFD*	1.07	0.29
rs3184504	12	*SH2B3*	1.07	0.40

(*Continued*)

Table 7-2. Continued

SNP	Chromosome	Gene	Effect Size (OR)	Effect Allele Frequency
rs4773144	13	*COL4A1-COL4A2*	1.07	0.42
rs9319428	13	*FLT1*	1.05	0.32
rs2895811	14	*HHIPL1*	1.06	0.43
rs7173743	15	*ADAMTS7*	1.07	0.58
rs17514846	15	*FURIN-FES*	1.05	0.44
rs2281727	17	*SMG6-SRR*	1.05	0.36
rs12936587	17	*RASD1-SMCR3-PEMT*	1.06	0.59
rs15563	17	*UBE2Z-GIP-ATP5G1-SNF8*	1.04	0.52
rs1122608	19	*LDLR*	1.10	0.76
rs2075650	19	*ApoE-ApoC1*	1.11	0.14
rs9982601	21	*KCNE2*	1.13	0.13

CAD indicates coronary artery disease; CARDIoGRAMplusC4D, Coronary Artery Disease Genome-wide Replication and Meta-analysis (CARDIOGRAM) plus the Coronary Artery Disease (C4D) Genetics Consortium; OR, odds ratio; and SNP, single-nucleotide polymorphism.

Data derived from Deloukas et al.[18]

Table 7-3. Heritability of CVD Risk Factors From the FHS

Trait	Heritability
ABI	0.21[35]
SBP	0.42[36]
DBP	0.39[36]
Left ventricular mass	0.24–0.32[37]
BMI	0.37 (mean age 40 y)–0.52 (mean age 60 y)[38]
Waist circumference	0.41[39]
Visceral abdominal fat	0.36[40]
Subcutaneous abdominal fat	0.57[40]
Fasting glucose	0.34[41]
CRP	0.30[42]
HbA_{1c}	0.27[41]
Triglycerides	0.48[43]
HDL-C	0.52[43]
Total cholesterol	0.57[43]
LDL-C	0.59[43]
Estimated GFR	0.33[44]

ABI indicates ankle-brachial index; BMI, body mass index; CRP, C-reactive protein; CVD, cardiovascular disease; DBP, diastolic blood pressure; FHS, Framingham Heart Study; GFR, glomerular filtration rate; HbA_{1c}, glycosylated hemoglobin; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; and SBP, systolic blood pressure.

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8. High Blood Cholesterol and Other Lipids

See Table 8-1 and Charts 8-1 through 8-4.

High cholesterol is a major risk factor for CVD and stroke.[1] The AHA has identified untreated TC <170 mg/dL (for children) and <200 mg/dL (for adults) as 1 of the 7 components of ideal cardiovascular health.[2] In 2011 to 2012, 75.7% of children and 46.6% of adults met these criteria.

Prevalence of High TC

For information on dietary cholesterol, total fat, saturated fat, and other factors that affect blood cholesterol levels, see Chapter 5 (Nutrition).

Youth

(See Chart 8-1.)

- Among children 6 to 11 years of age, the mean TC level is 160.2 mg/dL. For boys, it is 160.5 mg/dL; for girls, it is 159.8 mg/dL. The racial/ethnic breakdown is as follows (NHANES 2009–2012, unpublished NHLBI tabulation):
  - —For non-Hispanic whites, 158.6 mg/dL for boys and 158.2 mg/dL for girls
  - —For non-Hispanic blacks, 163.7 mg/dL for boys and 159.8 mg/dL for girls
  - —For Hispanics, 160.5 mg/dL for boys and 161.2 mg/dL for girls
- Among adolescents 12 to 19 years of age, the mean TC level is 158.3 mg/dL. For boys, it is 155.2 mg/dL; for girls, it is 161.6 mg/dL. The racial/ethnic breakdown is as follows (NHANES 2009–2012, unpublished NHLBI tabulation):
  - —For non-Hispanic whites, 155.2 mg/dL for boys and 163.2 mg/dL for girls
  - —For non-Hispanic blacks, 153.9 mg/dL for boys and 158.6 mg/dL for girls
  - —For Hispanics, 157.0 mg/dL for boys and 160.4 mg/dL for girls
- The prevalence of abnormal lipid levels among youths 12 to 19 years of age is 20.3%; 14.2% of normal-weight youths, 22.3% of overweight youths, and 42.9% of obese youths have ≥1 abnormal lipid level (NHANES 1999–2006, NCHS).[3]
- Approximately 8.5% of adolescents 12 to 19 years of age have TC levels ≥200 mg/dL (NHANES 2009–2012, unpublished NHLBI tabulation).
- Twenty percent of male adolescents and 27% of female adolescents have TC levels of 170 to 199 mg/dL.[4]
- Among youths aged 6 to 19 years, there was a decrease in mean TC from 165 to 160 mg/dL and a decrease in the prevalence of elevated TC from 11.3% to 8.1% from 1988 through 1994 to 2007 through 2010.[5]
- Mean non-HDL-C (111.7 mg/dL) and prevalence of elevated non-HDL-C both significantly decreased from the periods 1988 through 1994 to 2007 through 2010. In 2007 to 2010, 22% of youths had either a low HDL-C level or a high non-HDL-C level, which was lower than the 27.2% in 1988 to 1994.[5]
- Among adolescents (aged 12–19 years) between 1988 to 1994 and 2007 to 2010, there was a decrease in mean LDL-C from 95 to 90 mg/dL and a decrease in geometric mean triglycerides from 82 to 73 mg/dL. The prevalence of elevated LDL-C and triglycerides also decreased significantly between 1988 to 1994 and 2007 to 2010.[5]
- Fewer than 1% of adolescents are potentially eligible for pharmacological treatment on the basis of guidelines from the American Academy of Pediatrics.[3,6]

Adults

(See Table 8-1 and Charts 8-2 through 8-4.)

- An estimated 30.9 million adults ≥20 years of age have serum TC levels ≥240 mg/dL (extrapolated for 2012 by use of NCHS/NHANES 2009–2012 data), with a prevalence of 13.1%.
- Approximately 6.2% of adults ≥20 years of age have undiagnosed hypercholesterolemia, defined as a TC level ≥240 mg/dL and the participant having responded "no" to ever having been told by a doctor or other healthcare professional that the participant's blood cholesterol level was high (NHANES 2009–2012, unpublished NHLBI tabulation).
- In 2011 to 2012, an estimated 12.9% of US adults aged ≥20 years (11.1% of men and 14.4% of women) had high TC, defined as ≥240 mg/dL, which was unchanged since 2009 to 2010, according to NCHS/NHANES 2011 to 2012 data.[7]
  - —Non-Hispanic black adults had consistently lower percentages with high TC (9.8% overall, 7.4% for men, and 11.5% for women) than non-Hispanic white adults (13.5% overall, 11.6% for men, and 15.2% for women).[7]
  - —Overall, 14.2% of Hispanic adults had high TC.[7]
- The age-adjusted mean TC level for adults ≥20 years of age declined linearly from 206 mg/dL (95% CI, 205–207 mg/dL) in 1988 to 1994 to 203 mg/dL (95% CI, 201–205 mg/

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Abbreviations Used in Chapter 8

ACC	American College of Cardiology
AHA	American Heart Association
ASCVD	atherosclerotic cardiovascular disease
ATP III	Adult Treatment Panel III
BRFSS	Behavioral Risk Factor Surveillance System
CDC	Centers for Disease Control and Prevention
CHD	coronary heart disease
CI	confidence interval
CVD	cardiovascular disease
DALY	disability-adjusted life-year
DM	diabetes mellitus
HDL-C	high-density lipoprotein cholesterol
LDL-C	low-density lipoprotein cholesterol
Mex. Am.	Mexican American
NCHS	National Center for Health Statistics
NH	non-Hispanic
NHANES	National Health and Nutrition Examination Survey
NHLBI	National Heart, Lung, and Blood Institute
TC	total cholesterol
WHO	World Health Organization

dL) in 1999 to 2002 and to 196 mg/dL (95% CI, 195–198 mg/dL) in 2007 to 2010 (P<0.001 for linear trend).[8]

- Data from NHANES 2007 to 2010 (NCHS) showed the serum total crude mean cholesterol level in adults to be 194 mg/dL for men and 198 mg/dL for women.[8] Statistically significant declining trends in age-adjusted mean TC levels from 1988 through 1994 to 2007 through 2010 were observed in all sex and race/ethnicity subgroups except for Mexican American men (P=0.03). The Healthy People 2010 guideline[9] of an age-adjusted mean TC level of ≤200 mg/dL has been achieved in adults, in men, in women, and in all race/ethnicity and sex subgroups.
- Overall, the decline in cholesterol levels in recent years appears to reflect greater uptake of cholesterol-lowering medications rather than changes in dietary patterns.[10]
- The declining TC level appears to reflect a worldwide trend; a report on trends in TC in 199 countries and territories indicated that TC declined in high-income regions of the world (Australasia, North America, and Western Europe).[11] During the period from 1999 to 2006, 26.0% of adults had hypercholesterolemia, 9% of adults had both hypercholesterolemia and hypertension, 1.5% of adults had DM and hypercholesterolemia, and 3% of adults had all 3 conditions.[12]

Screening

- Data from the 2013 BRFSS study of the CDC show that the percentage of adults who had been screened for high cholesterol in the preceding 5 years ranged from 68.2% in Utah to 84.0% in Massachusetts. The median percentage among all 50 states was 76.4%.[13]
- The percentage of adults who reported having had a cholesterol check increased from 68.6% during 1999 to 2000 to 74.8% during 2005 to 2006[14] to 69.4% in 2011 to 2012.[7]
- Nearly 70% of adults (67% of men and nearly 72% of women) had been screened for cholesterol (defined as being told by a doctor their cholesterol was high and indicating they had their blood cholesterol checked <5 years ago) according to data from NHANES 2011 to 2012, which was unchanged since 2009 to 2010.[7]
  - —Among non-Hispanic whites, 71.8% were screened (70.6% of men and 72.9% of women).
  - —Among non-Hispanic blacks, 71.9% were screened (66.8% of men and 75.9% of women).
  - —Among non-Hispanic Asians, 70.8% were screened (70.6% of men and 70.9% of women).
  - —Among Hispanic adults, 59.3% were screened (54.6% of men and 64.2% of women). The percentage of adults screened for cholesterol in the past 5 years was lower for Hispanic adults than for non-Hispanic white, non-Hispanic black, and non-Hispanic Asian adults.

Awareness

- Data from the 2013 BRFSS study of the CDC showed that among adults screened for high cholesterol, the percentage who had been told that they had high cholesterol ranged from 33.4% in Utah to 44.4% in Alabama. The median percentage among states was 38.4%. The percentage of adults reporting having been screened for high blood cholesterol within the preceding 5 years increased overall from 72.7% in 2005 to 76.4% in 2013.[13]
- Among adults with hypercholesterolemia, 42% were told they had high TC in 1999 to 2000 compared with 50.4% during 2005 to 2006.[14]

Treatment

- In 2013, the ACC/AHA released a revised recommendation for statin treatment.[16] Unlike ATP III and other previous recommendations, which had LDL-C and non-HDL-C goals based on patient's risk category, the 2013 ACC/AHA guideline recommended lipid measurement at baseline, at 1 to 3 months after statin initiation, and then annually to check for the expected percentage decrease of LDL-C levels (30% to <50% with a moderate-intensity statin and ≥50% with a high-intensity statin). They also recommended a discussion regarding statin therapy in 4 identified groups in whom it has been clearly shown to reduce ASCVD risk. The 4 statin benefit groups are (1) people with clinical ASCVD, (2) those with primary elevations of LDL-C >190 mg/dL, (3) people aged 40 to 75 years who have DM with LDL-C 70 to 189 mg/dL and without clinical ASCVD, and (4) those without clinical ASCVD or DM with LDL-C 70 to 189 mg/dL and estimated 10-year ASCVD risk >7.5%. Approximately 31.9% of the ASCVD-free, nonpregnant US population between 40 and 79 years of age has a 10-year risk of a first hard CHD event of ≥10% or has DM.[17]
- According to a recent analysis of NHANES data from 2005 to 2010, the number of people eligible for statin therapy would rise from 43.2 million US adults (37.5%) to 56.0 million (48.6%) based on the new ACC/AHA guidelines for the management of blood cholesterol. Most of the increase comes from adults 60 to 75 years old without CVD who have a 10-year ASCVD risk ≥7.5%; the net number of new statin prescriptions could potentially increase by 12.8 million, including 10.4 million for primary prevention.[18] Individuals eligible for treatment under ATP III but not ACC/AHA guidelines had higher LDL-C levels but were otherwise at lower risk than individuals eligible under both guidelines or only under ACC/AHA guidelines.[19]
- NHANES data on the treatment of high LDL-C showed an increase from 28.4% of individuals during 1999 to 2002 to 48.1% during 2005 to 2008.[20]
- Self-reported use of cholesterol-lowering medications increased from 8.2% during 1999 to 2000 to 14% in 2005 to 2006[14] and reached 23% in 2007 to 2010.[21]
- During 2003 to 2012, the percentage of adults aged ≥40 years who had used a cholesterol-lowering mediation in the past 30 days increased from 20% to 28%.[22]

Adherence

Youth

- The American Academy of Pediatrics recommends screening for dyslipidemia in children and adolescents who have a family history of dyslipidemia or premature CVD, those whose family history is unknown, and those youths with risk factors for CVD, such as being overweight or obese, having hypertension or DM, or being a smoker.[3] In 2011, the NHBLI Expert Panel recommended universal dyslipidemia screening for all children between 9 and 11 years of age and again between 17 and 21 years of age.[23]

- Analysis of data from NHANES 1999 to 2006 showed that the overall prevalence of abnormal lipid levels among youths 12 to 19 years of age was 20.3%.[3]

Adults

- New criteria from the "2013 ACC/AHA Guideline on the Treatment of Blood Cholesterol to Reduce Atherosclerotic Cardiovascular Risk in Adults"[16] could result in >45 million middle-aged Americans who do not have CVD being recommended for consideration of statin therapy: 33.0 million are at ≥7.5% 10-year risk, and 12.8 million are at >5.0% to 7.4% 10-year risk. This is approximately 1 in every 3 American adults, many of whom are already undergoing statin treatment under the previous US guidelines.[24]
- On the basis of data from the 2005 to 2008 NHANES, an estimated 71 million US adults (33.5%) aged ≥20 years had high LDL-C, but only 34 million (48.1%) were treated and only 29.5% had their LDL-C controlled.[20]
  - —The proportion of adults with high LDL-C who were treated increased from 28.4% to 48.1% between the 1999 to 2002 and 2005 to 2008 study periods.
  - —Among adults with high LDL-C, the prevalence of LDL-C control increased from 14.6% to 33.2% between the periods. From 2005 to 2010, age-adjusted control of LDL-C increased from 22.3% to 29.5%.[25] The prevalence of LDL-C control was lowest among people who reported receiving medical care less than twice in the previous year (11.7%), being uninsured (13.5%), being Mexican American (20.3%), or having income below the poverty level (21.9%).

Global Burden of Hypercholesterolemia

- Between 1980 and 2008, the mean age-adjusted TC went from 4.72 to 4.64 mmol/L (95% uncertainty interval, 4.51–4.76) for men and from 4.83 to 4.76 mmol/L (95% uncertainty interval, 4.62–4.91) for women. Globally, mean TC changed little between 1980 and 2008, falling by <0.1 mmol/L per decade in men and women.[26]
- TC went from being the 14th leading risk factor in 1990 for the global burden of disease, as quantified by DALYs, to the number 15 risk factor in 2010.[27]
- Raised cholesterol, defined as ≥190 mg/dL or ≥5.0 mmol/L, is estimated to cause 2.6 million deaths (4.5% of total deaths) and 29.7 million DALYs (2.0% of total DALYs).[28]
- The prevalence of elevated TC was highest in the WHO European Region (54% for both sexes), followed by the WHO Region of the Americas (48% for both sexes). The WHO African Region and the WHO South-East Asia Region showed the lowest percentages (23% and 30%, respectively).[28]
- Twenty-nine percent of ischemic heart disease DALYs can be attributed to high TC, the second-leading physiological risk factor.[27]

Lipid Levels

LDL (Bad) Cholesterol

Youth

- There are limited data available on LDL-C for children 6 to 11 years of age.
- Among adolescents 12 to 19 years of age, the mean LDL-C level is 89.3 mg/dL (boys, 88.3 mg/dL; girls, 90.3 mg/dL). The racial/ethnic breakdown is as follows (NHANES 2009–2012, unpublished NHLBI tabulation):
  - —For non-Hispanic whites, 89.5 mg/dL for boys and 91.1 mg/dL for girls
  - —For non-Hispanic blacks, 86.7 mg/dL for boys and 90.9 mg/dL for girls
  - —For Hispanic Americans, 87.4 mg/dL for boys and 88.9 mg/dL for girls
- High levels of LDL-C occurred in 7.1% of male adolescents and 7.4% of female adolescents during 2009 to 2012 (unpublished NHLBI tabulation).

Adults

- The mean level of LDL-C for American adults ≥20 years of age was 115.8 mg/dL in 2009 to 2012 (unpublished NHLBI tabulation).
- According to NHANES 2009 to 2012 (unpublished NHLBI tabulation):
  - —Among non-Hispanic whites, mean LDL-C levels were 113.8 mg/dL for men and 116.8 mg/dL for women.
  - —Among non-Hispanic blacks, mean LDL-C levels were 113.4 mg/dL for men and 115.5 mg/dL for women.
  - —Among Hispanics, mean LDL-C levels were 120.1 mg/dL for men and 114.8 mg/dL for women.
- The prevalence of high LDL-C decreased from 59% in 1976 to 1980 to 42% in 1988 to 1994 and to 33% in 2001 to 2004, reaching 27% in 2007 to 2010. Between 1976 to 1980 and 2007 to 2010, the prevalence of high LDL-C decreased significantly for men (from 65% to 31%), women (54% to 24%), and adults aged 40 to 64 years (56% to 27%) and 65 to 74 years (72% to 30%).[21]
- The age-adjusted prevalence of high LDL-C in US adults was 26.6% in 1988 to 1994 and 25.3% in 1999 to 2004 (NHANES/NCHS). Between 1988 to 1994 and 1999 to 2004, awareness increased from 39.2% to 63.0%, and use of pharmacological lipid-lowering treatment increased from 11.7% to 40.8%. LDL-C control increased from 4.0% to 25.1% among those with high LDL-C. In 1999 to 2004, rates of LDL-C control were lower among adults 20 to 49 years of age than among those ≥65 years of age (13.9% versus 30.3%, respectively), among non-Hispanic blacks and Mexican Americans than among non-Hispanic whites (17.2% and 16.5% versus 26.9%, respectively), and among men than among women (22.6% versus 26.9%, respectively).[29]
- Mean levels of LDL-C decreased from 126.2 mg/dL during 1999 to 2000 to 115.5 mg/dL during 2011 to 2012. The age-adjusted prevalence of high LDL-C decreased from 42.9% during 1999 to 2000 to 32.2% during 2011 to 2012 (unpublished NHLBI tabulation).
- Data from NHANES 2005 to 2006 indicate that among those with elevated LDL-C levels, 35.5% had not been screened previously, 24.9% were screened but not told they had elevated cholesterol, and 39.6% were treated inadequately.[21]
- Data from NHANES 1999 to 2006 indicate that among those at high risk for CHD with elevated LDL-C levels,

roughly two thirds of those eligible for medication did not receive treatment.[30]

HDL (Good) Cholesterol

Youth

- Among children 6 to 11 years of age, the mean HDL-C level is 53.9 mg/dL. For boys, it is 55.4 mg/dL, and for girls, it is 52.4 mg/dL. The racial/ethnic breakdown is as follows (NHANES 2009–2012, unpublished NHLBI tabulation):
  - —For non-Hispanic whites, 55.1 mg/dL for boys and 52.5 mg/dL for girls
  - —For non-Hispanic blacks, 58.5 mg/dL for boys and 54.5 mg/dL for girls
  - —For Hispanics, 53.5 mg/dL for boys and 51.4 mg/dL for girls
- Among adolescents 12 to 19 years of age, the mean HDL-C level is 51.4 mg/dL. For boys, it is 49.4 mg/dL, and for girls, it is 53.4 mg/dL. The racial/ethnic breakdown is as follows (NHANES 2009–2012, unpublished NHLBI tabulation):
  - —For non-Hispanic whites, 48.9 mg/dL for boys and 52.4 mg/dL for girls
  - —For non-Hispanic blacks, 52.6 mg/dL for boys and 55.1 mg/dL for girls
  - —For Hispanics, 48.1 mg/dL for boys and 53.6 mg/dL for girls
- Low levels of HDL-C occurred in 19.5% of male adolescents and 11.1% of female adolescents during 2009 to 2012 (NHANES 2009–2012, unpublished NHLBI tabulation).

Adults

- The mean level of HDL-C for American adults ≥20 years of age is 52.9 mg/dL (NHANES 2009–2012, unpublished NHLBI tabulation).
- According to NHANES 2009 to 2012 (unpublished NHLBI tabulation):
  - —Among non-Hispanic whites, mean HDL-C levels were 47.7 mg/dL for men and 58.5 mg/dL for women.
  - —Among non-Hispanic blacks, mean HDL-C levels were 51.9 mg/dL for men and 57.4 mg/dL for women.
  - —Among Hispanics, mean HDL-C levels were 45.4 mg/dL for men and 54.3 mg/dL for women.
- Approximately 17% of adults (just over one quarter of men and <10% of women) had low HDL-C during 2011 to 2012. The percentage of adults with low HDL-C has decreased 20% since 2009 to 2010.[7]
  - —Among non-Hispanic whites, 17.1% (25.4% of men and 9.3% of women) had low HDL-C.
  - —Among non-Hispanic blacks, 12.7% (19.1% of men and 7.8% of women) had low HDL-C. The percentage of adults with low HDL-C was lower in non-Hispanic black adults than in non-Hispanic white adults. These racial and ethnic differences were also observed in men but not in women.
  - —Among non-Hispanic Asians, 14.3% (24.5% of men and 5.1% of women) had low HDL-C. The prevalence of low HDL-C was 5 times greater among non-Hispanic Asian men than women. Non-Hispanic Asian adults had consistently lower percentages of low HDL-C than Hispanic adults.
- The prevalence of low HDL-C was 5 times higher in non-Hispanic Asian men (24.5%) than in non-Hispanic Asian women (5.1%).[31]
- Among Hispanic adults, 21.8% (32.6% of men and 11.3% of women) had low HDL-C. The percentage of adults with low HDL-C was higher in Hispanic adults than in non-Hispanic black or non-Hispanic white adults. These racial and ethnic differences were also observed in men but not in women.

Triglycerides

Youth

- There are limited data available on triglycerides for children 6 to 11 years of age.
- Among adolescents 12 to 19 years of age, the geometric mean triglyceride level is 82.1 mg/dL. For boys, it is 84.6 mg/dL, and for girls, it is 79.5 mg/dL. The racial/ethnic breakdown is as follows (NHANES 2009–2012):
  - —Among non-Hispanic whites, 83.1 mg/dL for boys and 82.4 mg/dL for girls
  - —Among non-Hispanic blacks, 70.4 mg/dL for boys and 62.2 mg/dL for girls
  - —Among Hispanics, 90.3 mg/dL for boys and 84.9 mg/dL for girls
- High levels of triglycerides occurred in 10.0% of male adolescents and 6.5% of female adolescents during 2009 to 2012.

Adults

- The geometric mean level of triglycerides for American adults ≥20 years of age is 108.8 mg/dL (NHANES 2009–2012, unpublished NHLBI tabulation).
- Approximately 25.1% of adults had high triglyceride levels (>150 mg/dL) during 2009 to 2012 (NHANES 2009–2012, unpublished NHLBI tabulation).
- Among men, the age-adjusted geometric mean triglyceride level is 117.2 mg/dL (NHANES 2009–2012, unpublished NHLBI tabulation), with the following racial/ethnic breakdown:
  - —117.7 mg/dL for non-Hispanic white men
  - —92.7 mg/dL for non-Hispanic black men
  - —134.7 mg/dL for Hispanic men
- Among women, the age-adjusted geometric mean triglyceride level is 101.4 mg/dL (NHANES 2009–2012, unpublished NHLBI tabulation), with the following racial/ethnic breakdown:
  - —104.0 mg/dL for non-Hispanic white women
  - —83.5 mg/dL for non-Hispanic black women
  - —109.7 mg/dL for Hispanic women
- Fewer than 3% of adults with a triglyceride level ≥150 mg/dL received pharmacological treatment during 1999 to 2004.[32]

Table 8-1. High TC and LDL-C and Low HDL-C

Population Group	Prevalence of TC ≥200 mg/dL, 2012 Age ≥20 y	Prevalence of TC ≥240 mg/dL, 2012 Age ≥20 y	Prevalence of LDL-C ≥130 mg/dL, 2012 Age ≥20 y	Prevalence of HDL-C <40 mg/dL, 2012 Age ≥20 y
Both sexes, n (%)*	100 100 000 (42.8)	30 900 000 (13.1)	73 500 000 (31.7)	44 600 000 (19.9)
Males, n (%)*	45 300 000 (40.4)	13 000 000 (11.6)	34 900 000 (31.0)	32 400 000 (28.9)
Females, n (%)*	54 830 000 (44.9)	17 900 000 (14.4)	38 600 000 (32.0)	12 200 000 (10.4)
NH white males, %	39.9	11.5	29.4	28.7
NH white females, %	45.9	15.3	32.0	10.2
NH black males, %	37.4	8.8	30.7	20.0
NH black females, %	40.7	10.9	33.6	10.3
Hispanic males, %	46.2	14.8	38.8	33.8
Hispanic females, %	43.4	13.7	31.8	12.8

Prevalence of TC ≥200 mg/dL includes people with TC ≥240 mg/dL. In adults, levels of 200 to 239 mg/dL are considered borderline high. Levels of ≥240 mg/dL are considered high. HDL-C indicates high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; NH, non-Hispanic; and TC, total cholesterol.

*Total data for TC are for Americans ≥20 years of age. Data for LDL-C, HDL-C, and all racial/ethnic groups are age adjusted for age ≥20 years.

Source for TC ≥200 mg/dL, ≥240 mg/dL, LDL-C, and HDL-C: National Health and Nutrition Examination Survey (2009–2012), National Center for Health Statistics, and National Heart, Lung, and Blood Institute. Estimates from National Health and Nutrition Examination Survey 2009 to 2012 (National Center for Health Statistics) were applied to 2012 population estimates.

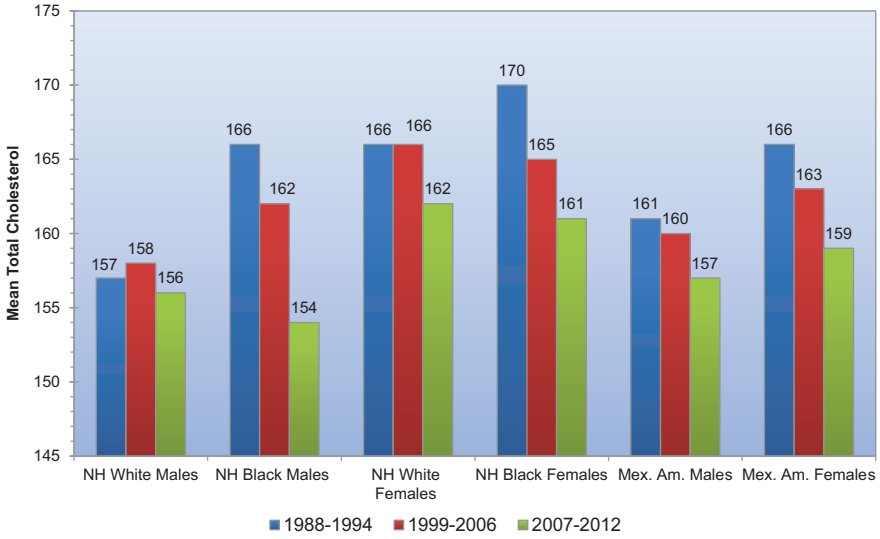

Chart 8-1. Trends in mean serum total cholesterol among adolescents 12 to 19 years of age by race, sex, and survey year (National Health and Nutrition Examination Survey: 1988–1994, 1999–2006, and 2007–2012). Values are in mg/dL. Mex. Am. indicates Mexican American; and NH, non-Hispanic. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

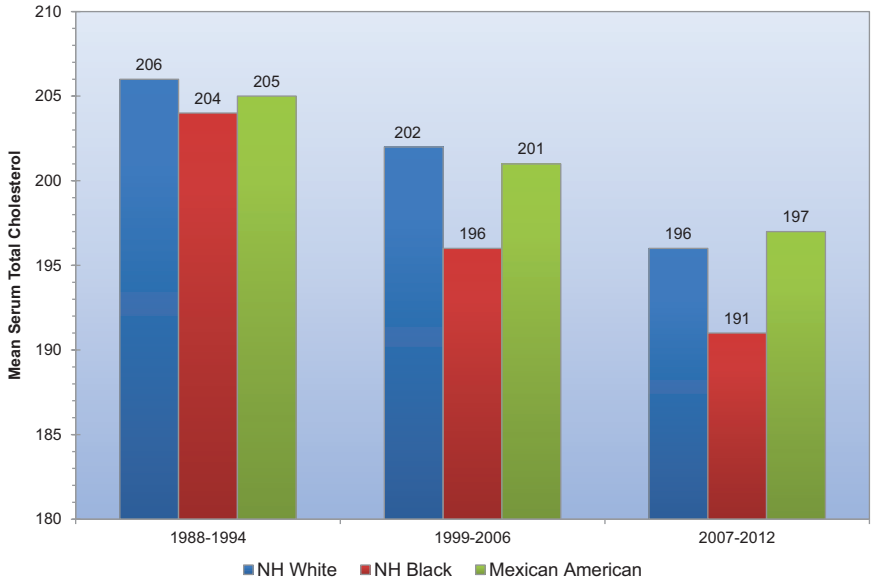

Chart 8-2. Age-adjusted trends in mean serum total cholesterol among adults ≥20 years old by race and survey year (National Health and Nutrition Examination Survey: 1988–1994, 1999–2006, and 2007–2012). Values are in mg/dL. NH indicates non-Hispanic. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

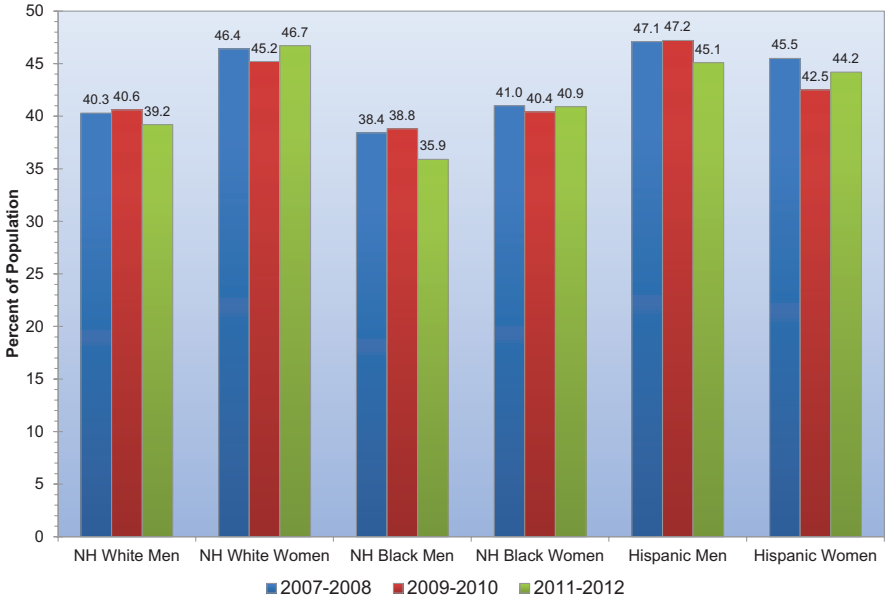

Chart 8-3. Age-adjusted trends in the prevalence of serum total cholesterol ≥200 mg/dL in adults ≥20 years of age by sex, race/ethnicity, and survey year (National Health and Nutrition Examination Survey 2007–2008, 2009–2010, and 2011–2012). NH indicates non-Hispanic.

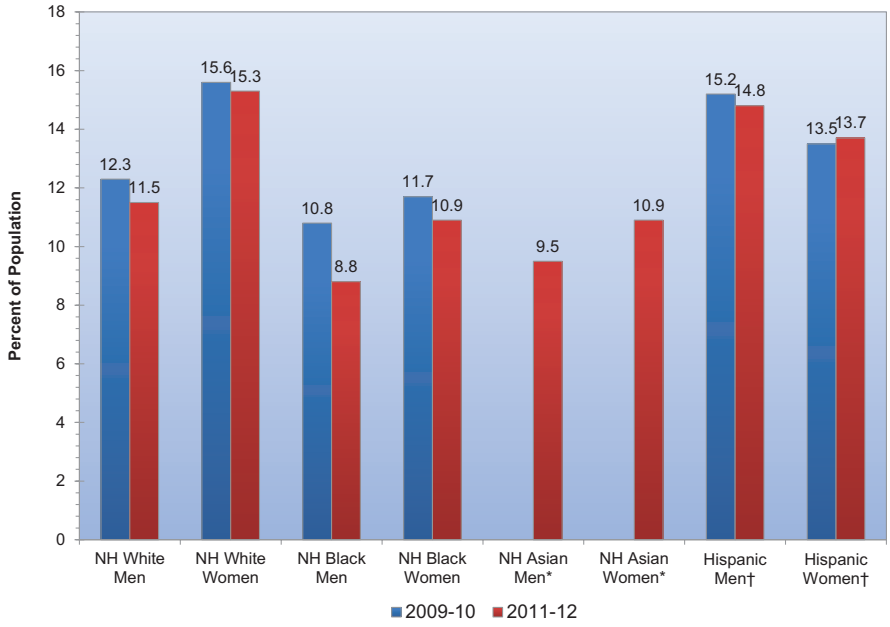

Chart 8-4. Age-adjusted trends in the prevalence of serum total cholesterol ≥240 mg/dL in adults ≥20 years of age by sex, race/ethnicity, and survey year (National Health and Nutrition Examination Survey 2009–2010 and 2011–2012). NH indicates non-Hispanic. *Data not available for non-Hispanic Asians in 2009 to 2010. †2009 to 2010 data are for Mexican Americans only.

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9. High Blood Pressure

ICD-9 401 to 404, ICD-10 I10 to I15. See Tables 9-1 and 9-2 and Charts 9-1 through 9-5.

HBP is a major risk factor for CVD and stroke.[1] The AHA has identified untreated BP <90th percentile (for children) and <120/<80 mm Hg (for adults aged ≥20 years) as 1 of the 7 components of ideal cardiovascular health.[2] In 2011 to 2012, 82.3% of children and 42.2% of adults met these criteria (Chapter 2, Cardiovascular Health).

Prevalence

(See Table 9-1 and Chart 9-1.)

- Surveillance definitions vary widely in the published literature.[3]
- For surveillance purposes, the following definition of HBP has been proposed[3]:
  - —SBP ≥140 mm Hg or DBP ≥90 mm Hg or taking antihypertensive medicine, or
  - —Having been told at least twice by a physician or other health professional that one has HBP.
- With this definition, the prevalence of hypertension (age adjusted) among US adults ≥20 years of age was estimated to be 32.6% in NHANES 2009 to 2012. This equates to an estimated 80.0 million adults ≥20 years of age who have HBP (38.3 million men and 41.7 million women), extrapolated to 2012 data (Table 9-1).
- In 2009 to 2012, the age-adjusted prevalence of hypertension was 44.9% and 46.1% among non-Hispanic black men and women, respectively; 32.9% and 30.1% among non-Hispanic white men and women, respectively; and 29.6% and 29.9% among Hispanic men and women, respectively.
- NHANES data show that a higher percentage of men than women have hypertension until 45 years of age. From 45 to 54 years of age and from 55 to 64 years of age, the percentages of men and women with hypertension are similar. After that, a higher percentage of women have hypertension than men (Chart 9-1).
- The prevalence of hypertension increased between 1988 to 1994, 1999 to 2006, and 2007 to 2012 among non-Hispanic black men (37.5%, 39.5%, and 40.1%, respectively) and women (38.2%, 41.7%, and 42.9%, respectively), non-Hispanic men (25.6%, 28.7%, and 30.1%, respectively) and women (22.9%, 27.8%, and 27.7%, respectively), and Mexican American women (25.0%, 26.1%, and 27.0%, respectively) but not Mexican American men (26.9%, 24.3%, and 26.6%, respectively).
- Data from NHANES 2011 to 2012 found that 17.2% of US adults are not aware they have hypertension.[4]
- Data from the 2007 to 2008 BRFSS, NHIS, and NHANES surveys found 27.8%, 28.5%, and 30.7% of US adults, respectively, had been told they had hypertension.[5]

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Abbreviations Used in Chapter 9

AHA	American Heart Association
BMI	body mass index
BP	blood pressure
BRFSS	Behavioral Risk Factor Surveillance System
CARDIA	Coronary Artery Risk Development in Young Adults
CDC	Centers for Disease Control and Prevention
CHD	coronary heart disease
CI	confidence interval
CKD	chronic kidney disease
CRP	C-reactive protein
CVD	cardiovascular disease
DALY	disability-adjusted life-year
DBP	diastolic blood pressure
DM	diabetes mellitus
ED	emergency department
ESRD	end-stage renal disease
FHS	Framingham Heart Study
HBP	high blood pressure
HCHS/SOL	Hispanic Community Health Study/Study of Latinos
HD	heart disease
HR	hazard ratio
ICD-9	*International Classification of Diseases, 9th Revision*
ICD-9-CM	*International Classification of Diseases, Clinical Modification, 9th Revision*
ICD-10	*International Classification of Diseases, 10th Revision*
JAMA	*Journal of the American Medical Association*
JNC	Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure
MEPS	Medical Expenditure Panel Survey
MESA	Multi-Ethnic Study of Atherosclerosis
MI	myocardial infarction
NAMCS	National Ambulatory Medical Care Survey
NCHS	National Center for Health Statistics
NH	non-Hispanic
NHAMCS	National Hospital Ambulatory Medical Care Survey
NHANES	National Health and Nutrition Examination Survey
NHDS	National Hospital Discharge Survey
NHIS	National Health Interview Survey
NHLBI	National Heart, Lung, and Blood Institute
NNHS	National Nursing Home Survey
OR	odds ratio
PA	physical activity
PAR	population attributable risk
REGARDS	Reasons for Geographic and Racial Differences in Stroke
RR	relative risk
SBP	systolic blood pressure
SEARCH	Search for Diabetes in Youth Study

- Among those 18 to 39 years of age, prevalence was 7.3%; among those 40 to 59 years of age, prevalence was 32.4%; and among those ≥60 years of age, prevalence was 65.0%.[4]
- Oral contraceptive use was less common among women with than among those without hypertension.[6]
- Data from NHANES 2011 to 2012 estimated the prevalence of hypertension in men and women ≥18 years of age to be 29.7% and 28.5%, respectively.[4]
- Data from the 2013 BRFSS/CDC indicate that the percentage of adults ≥18 years of age who had been told that they had HBP ranged from 25.5% in Minnesota and Colorado to 38.3% in Louisiana. The mean percentage for the United States was 30.4%.[7]
- According to 2005 to 2008 NHANES data, among US adults with hypertension, 11.8% met the criteria for resistant hypertension (SBP/DBP ≥140/90 mm Hg and reported use of antihypertensive medications from 3 different drug classes or drugs from ≥4 antihypertensive drug classes regardless of BP). This represents an increase from 5.5% in 1998 to 1994 and 8.5% in 1999 to 2004.[8]
- The "2014 Evidence-Based Guideline for the Management of High Blood Pressure in Adults" report recommends a higher SBP threshold (150 mm Hg) for treatment initiation and goal attainment in adults ≥60 years of age without DM or CKD. Additionally, the SBP treatment/goal threshold increased from 130 to 140 mm Hg among individuals with DM or CKD. The DBP goal remained at 90 mm Hg.[9] This change should have minimal impact on the percentage of US adults <60 years of age with hypertension.
  - —The prevalence of hypertension using the 2014 definition versus the JNC 7 definition declined from 20.3% to 19.2%.[10] Among US adults ≥60 years of age, the percentage with hypertension decreased from 68.9% to 61.2% between JNC 7 and the 2014 definition, with above-goal BP declining from 41.3% to 20.9%.[10]
  - —In 2005 to 2010, more US adults ≥60 years of age had SBP ≥150 mm Hg than between 140 and 149 mm Hg.[11]
- Projections show that by 2030, ≈41.4% of US adults will have hypertension, an increase of 8.4% from 2012 estimates (unpublished AHA computation, based on methodology described by Heidenreich et al[12]).

Older Adults

- In 2009 to 2010, hypertension was among the diagnosed chronic conditions that were more prevalent among older (≥65 years of age) women than older men (57% prevalence for women, 54% for men). Ever-diagnosed conditions that were more prevalent among older men than older women included HD (37% for men, 26% for women) and DM (24% for men, 18% for women), on the basis of data from NHIS/NCHS.[13]
- The age-adjusted prevalence of hypertension (both diagnosed and undiagnosed) in 2003 to 2006 was 75% for older women and 65% for older men on the basis of data from NHANES/NCHS.[14]
- Data from the 2004 NNHS revealed the most frequent chronic medical condition among this nationally representative sample of long-term stay nursing home residents aged ≥65 years was hypertension (53% of men and 56% of women). In men, prevalence of hypertension decreased with increasing age.[15]
- Among US adults ≥60 years of age in NHANES 2011 to 2012, prevalence of hypertension was 65.0%, awareness of hypertension was 86.1%, treatment for hypertension was 82.2%, and control of hypertension was 50.5%.[4]
- Data from NHANES 2005 to 2010 found that 76.5% of US adults ≥80 years of age had hypertension.[16]
- In 2005 to 2010, 30.9% of US adults ≥80 years of age were taking ≥3 classes of antihypertensive medication. This represents an increase from 7.0% and 19.2% in 1988 to 1994 and 1999 to 2004, respectively.[16]

Children and Adolescents

- In 2011 to 2012, 11.0% (95% CI, 8.8%–13.4%) of children and adolescents aged 8 to 17 years had either HBP or borderline HBP. No change occurred in the prevalence of borderline HBP (7.6% [95% CI, 5.8%–9.8%] versus 9.4% [95% CI, 7.2%–11.9%]; P=0.90) or either HBP or borderline HBP (10.6% [8.4%–13.1%] versus 11.0% [95% CI, 8.8%–13.4%]; P=0.26) between 1999 to 2000 and 2011 to 2012.[17]
- In 2011 to 2012, HBP was more common among boys (1.8%) than girls (1.4%) and among Hispanics than non-Hispanic blacks, non-Hispanic whites, and non-Hispanic Asians (1.7%). Although having either HBP or borderline HBP was more common among boys than girls, non-Hispanic blacks were more likely to have either HBP or borderline HBP than Hispanic, non-Hispanic white, or non-Hispanic Asian boys or girls.[17]
- In 2003 to 2010, the distribution of poor, intermediate, and ideal BP among children 8 to 11 years of age was 2.8%, 4.8%, and 92.5%, respectively, among boys and 3.5%, 5.0%, and 91.5%, respectively, among girls.[18]
- Data from participants aged 12 to 19 years in the 2005 to 2010 NHANES found ideal BP (<95th percentile) to be present in 78% of males and 90% of females; poor BP (>95th percentile) was found in 2.9% of male and 3.7% of female participants.[19]
- Analysis of data from NHANES III (1988–1994) and NHANES 1999 to 2008 found the prevalence of elevated BP (SBP or DBP ≥90th percentile or SBP/DBP ≥120/80 mm Hg) increased from 15.8% to 19.2% among boys and from 8.2% to 12.6% among girls.[20]
- In a study of 237 248 youths aged 6 to 17 years in a large managed care setting, 31.4% had prehypertension (90th to 94th percentiles), and 16.6% had hypertension (≥95th percentile) based on a single visit. After an additional visit, the prevalence of hypertension (≥95th percentile at both visits) was confirmed to be present in only 4.8%. The prevalence of confirmed hypertension (≥95th percentile elevated on ≥3 occasions (or ≥140/90 mm Hg even if lower than the 90th percentile)) was 2.1% and was higher in Hispanics and Asian/Pacific Islanders than in non-Hispanic whites or blacks.[21]

- Analysis of the National Health Examination Survey, the Hispanic Health and Nutrition Examination Survey, and the NHANES/NCHS surveys of the NCHS (1963–2002) found that the BP, pre-HBP, and HBP trends in children and adolescents 8 to 17 years of age moved downward from 1963 to 1988 and upward thereafter. Pre-HBP and HBP increased 2.3% and 1%, respectively, between 1988 and 1999. Increased obesity (abdominal obesity more so than general obesity) partially explained the HBP and pre-HBP rise from 1988 to 1999. BP and HBP reversed their downward trends 10 years after the increase in the prevalence of obesity. In addition, an ethnic and sex gap appeared in 1988 for pre-HBP and in 1999 for HBP: non-Hispanic blacks and Mexican Americans had a greater prevalence of HBP and pre-HBP than non-Hispanic whites, and the prevalence was greater in boys than in girls. In that study, HBP in children and adolescents was defined as SBP or DBP that was, on repeated measurement, ≥95th percentile.[22]
- A study in Ohio of >14 000 children and adolescents 3 to 18 years of age who were observed at least 3 times between 1999 and 2006 found that 507 children (3.6%) had hypertension. Of these, 131 (26%) had been diagnosed and 376 (74%) were undiagnosed. In addition, 3% of those with hypertension had stage 2 hypertension, and 41% of those with stage 2 hypertension were undiagnosed. Criteria for prehypertension were met by 485 children. Of these, 11% were diagnosed. In this study, HBP in children and adolescents was defined as SBP or DBP that was, on repeated measurement, ≥95th percentile.[23]
- Analysis of data from the SEARCH study, which included children 3 to 17 years of age with type 1 and type 2 DM, found the prevalence of elevated BP to be 5.9% among those with type 1 DM and 23.7% among those with type 2 DM.[24]
- Longitudinal BP outcomes from the National Childhood Blood Pressure database (ages 13–15 years) were examined after a single BP measurement. Among those determined to have prehypertension, 14% of boys and 12% of girls had hypertension 2 years later; the overall rate of progression from prehypertension to hypertension was ≈7%.[25]
- The AHA has outlined conditions in which ambulatory BP monitoring may be helpful in children and adolescents. These include secondary hypertension, CKD, type 1 and type 2 DM, obesity, sleep apnea, genetic syndromes, treated patients with hypertension, and for research.[26]

Race/Ethnicity and HBP

(See Table 9-1 and Chart 9-2.)

- The prevalence of hypertension in blacks in the United States is among the highest in the world. From 1988 to 1994 through 1999 to 2002, the prevalence of HBP in adults increased from 35.8% to 41.4% among blacks, and it was particularly high among black women at 44.0%. Prevalence among whites also increased, from 24.3% to 28.1%.[27]
- From 1999 to 2000 through 2009 to 2010, the prevalence of hypertension did not increase among non-Hispanic black men (38.0% and 39.6% in 1999–2000 and 2009–2010, respectively) or women (40.8% and 43.1% in 1999–2000 and 2009–2010, respectively).[28]
- In 2011 to 2012, non-Hispanic blacks had a higher prevalence of hypertension (42.1%) than non-Hispanic whites (28.0%), Hispanics (24.7%), and non-Hispanic Asians (24.7%).[4]
- Compared with whites, blacks develop HBP earlier in life, and their average BP is much higher.[29,30]
- The incidence of hypertension is higher for blacks than whites through 75 years of age; for a 45-year-old without hypertension, the 40-year risk for hypertension is 92.7% among blacks, 92.4% among Hispanics, 86.0% among whites, and 84.1% among Asians.[31]
- African Americans are more likely than whites to have nondipping BP and nighttime hypertension on ambulatory BP monitoring.[32]
- In a study of 18 865 adults in the southeastern United States, blacks were more likely to transition from prehypertension to hypertension than whites (adjusted HR, 1.35; 95% CI, 1.30–1.40).[33]
- Compared with whites, blacks have a 1.3 times greater rate of nonfatal stroke, a 1.8 times greater rate of fatal stroke, a 1.5 times greater rate of death attributable to HD, and a 4.2 times greater rate of ESRD (fifth and sixth reports of the JNC).
- The same increment in SBP is associated with a higher stroke risk for blacks than for whites.[34,35]
- Higher SBP explains ≈50% of the excess risk among blacks compared with whites.[36]
- Data from the 2014 NHIS showed that black adults 18 years of age were more likely (33.0%) to have been told on ≥2 occasions that they had hypertension than American Indian/Alaska Native adults (26.4%), white adults (23.5%), Hispanic or Latino adults (22.9%), or Asian adults (19.5%).[37]
- In the HCHS/SOL, the age-standardized prevalence of hypertension ranged from a low of 19.9% among US men from South America to 32.6% among their counterparts from the Dominican Republic. For US women, the age-standardized prevalence of hypertension was lowest for those of South American descent (15.9%) and highest for their counterparts from Puerto Rico (29.1%).[38]
- Also in the HCHS/SOL, there was substantial heterogeneity in awareness, treatment, and control of hypertension, with Central Americans having the lowest prevalence and Cubans having the highest prevalence among men. Among women, South Americans had the lowest prevalence of awareness and treatment, whereas hypertension control was lowest among Central American women. Only Hispanic women reporting mixed/other origin had a hypertension control rate that exceeded 50%.[39]
- Among NHIS 1997 to 2005 respondents, hypertension prevalence was higher among US-born adults than among foreign-born adults (adjusted OR, 1.28; 95% CI, 1.21–1.36). Hypertension prevalence was higher among US-born non-Hispanic blacks than either foreign-born non-Hispanic blacks (adjusted OR, 1.24; 95% CI, 1.02–1.50) or all African-born immigrants of any race/ethnicity (adjusted OR, 1.45; 95% CI, 1.07–1.97).[40]
- Among US-born participants in the 2001, 2003, 2005, and 2007 California Health Interview Survey, Hispanics from Central America and South America were less likely to self-report hypertension than non-Hispanic whites.

These differences were not present among foreign-born participants.[41]
- Data from MESA found that being born outside the United States, speaking a language other than English at home, and living fewer years in the United States were each associated with a decreased prevalence of hypertension.[42]
- Filipino (27%) and Japanese (25%) adults were more likely than Chinese (17%) or Korean (17%) adults to have ever been told that they had hypertension.[43]

Mortality

(See Table 9-1.)

- In 2013, there were 71 942 deaths attributable to HBP. In 2013, there were 405 541 any-mention deaths for HBP. The 2013 death rate was 19.9. Death rates were 18.9 for non-Hispanic white males, 51.6 for non-Hispanic black males, 20.0 for Hispanic males, 15.8 for non-Hispanic white females, 36.5 for non-Hispanic black females, and 15.3 for Hispanic females.[44]
- From 2003 to 2013, the death rate attributable to HBP increased 8.2%, and the actual number of deaths rose 34.7% (NHLBI tabulation).[45] During this 10-year period, in non-Hispanic whites, the HBP death rate increased 14.4%, whereas the actual number of deaths increased 34.3%. In non-Hispanic blacks, the HBP death rate decreased 9.1%, whereas the actual number of deaths increased 20.3%. In Hispanics, the HBP death rate increased 1.7%, and the actual number of deaths increased 75.5%.[44]
- When any-mention mortality for 2013 was used, the overall death rate was 112.9. Death rates were 119.2 for non-Hispanic white males, 221.9 for non-Hispanic black males, 91.7 for non-Hispanic Asian or Pacific Islander males, 140.8 for non-Hispanic American Indian or Alaska Native males (underestimated because of underreporting), and 117.2 for Hispanic males. In females, rates were 93.5 for non-Hispanic white females, 159.7 for non-Hispanic black females, 68.8 for non-Hispanic Asian or Pacific Islander females, 105.7 for non-Hispanic American Indian or Alaska Native females (underestimated because of underreporting), and 88.0 for Hispanic females.[44]
- Among US adults with hypertension followed up from 1971 to 1975 through 1992, age-adjusted mortality was 18.8 per 1000 person-years. This declined to 14.3 per 1000 person-years between 1988 to 1994 and 2006. This rate of decline was also observed for individuals without hypertension, and in both time periods, US adults with hypertension had higher mortality than their counterparts without hypertension.[46]
- A mathematical model was developed to estimate the number of deaths that potentially could be prevented annually by increasing the use of 9 clinical preventive services. The model predicted that a 10% increase in hypertension treatment would result in ≈14 000 deaths prevented.[47]
- Data from the Harvard Alumni Health Study found that higher BP in early adulthood was associated several decades later with higher risk for all-cause mortality, CVD mortality, and CHD mortality but not stroke mortality.[48]
- An analysis of NHANES I and III that compared mortality over time in hypertensive and nonhypertensive US adults found a reduction in the age-adjusted mortality rate from 18.8 per 1000 person-years for NHANES I (follow-up: 1971–1992) to 14.3 for NHANES III (follow-up: 1988–2006) among people with hypertension. The reduction was higher in men than in women but was similar for blacks and whites.[46]
- Compared with other dietary, lifestyle, and metabolic risk factors, HBP is the leading cause of death in women and the second-leading cause of death in men, behind smoking.[49]
- The CDC analyzed death certificate data from 1995 to 2002 (any-mention hypertension mortality; *ICD-9* codes 401–404 and *ICD-10* codes I10–I13). The results indicated that Puerto Rican Americans had a consistently higher hypertension-related death rate than all other Hispanic subpopulations and non-Hispanic whites. The age-standardized hypertension-related mortality rate was 127.2 per 100 000 population for all Hispanics, similar to that of non-Hispanic whites (135.9). The age-standardized rate for Hispanic females (118.3) was substantially lower than that observed for Hispanic males (135.9). Hypertension-related mortality rates for males were higher than rates for females for all Hispanic subpopulations. Puerto Rican Americans had the highest hypertension-related death rate among all Hispanic subpopulations (154.0); Cuban Americans had the lowest (82.5).[50]
- Assessment of 30-year follow-up of the Hypertension Detection and Follow-up Program identified the long-term benefit of stepped care, as well as the increased survival for hypertensive African Americans, although disparities in death rates did persist.[51]
- Assessment of the Charleston Heart Study and Evans County Heart Study identified the excess burden of elevated BP for African Americans and its effect on long-term health outcomes.[52]

Risk Factors

- Numerous risk factors and markers for development of hypertension have been identified, including age, race/ethnicity, family history of hypertension and genetic factors, lower education and socioeconomic status, greater weight, lower PA, tobacco use, psychosocial stressors, sleep apnea, and dietary factors (including dietary fats, higher sodium intake, lower potassium intake, and excessive alcohol intake).
- A study of related individuals in the NHLBI's FHS suggested that different sets of genes regulate BP at different ages.[53]
- Data from the Nurses' Health Study suggest that a large proportion of incident hypertension in women can be prevented by controlling dietary and lifestyle risk factors.[54]
- Risk prediction models for developing hypertension have been developed and validated. A commonly used risk prediction model was developed in the FHS and includes age, sex, SBP, DBP, BMI, smoking, and parental history of hypertension.[55,56] In young adults, this model was better able to identify those developing hypertension over 25 years of follow-up than prehypertension; however, this model systematically underestimated the risk for hypertension.[57]

Aftermath

- Data from the FHS/NHLBI indicate that recent (within the past 10 years) and remote antecedent BP levels may be an important determinant of risk over and above the current BP level.[58]
- Data from the FHS/NHLBI indicate that hypertension is associated with shorter overall life expectancy, shorter life expectancy free of CVD, and more years lived with CVD.[59]
  - —Total life expectancy was 5.1 years longer for normotensive men and 4.9 years longer for normotensive women than for hypertensive people of the same sex at 50 years of age.
  - —Compared with hypertensive men at 50 years of age, men with untreated BP <140/90 mm Hg survived on average 7.2 years longer without CVD and spent 2.1 fewer years of life with CVD. Similar results were observed for women.

Hospital Discharges/Ambulatory Care Visits

(See Table 9-1.)

- From 2000 to 2010, the number of inpatient discharges from short-stay hospitals with HBP as the first-listed diagnosis increased from 457 000 to 488 000 (no significant difference; NCHS, NHDS). The number of all-listed discharges increased from 8 034 000 to 11 282 000 (NHLBI, unpublished data from the NHDS, 2010; diagnoses in 2010 were truncated at 7 diagnoses for comparability with earlier year).
- Data from the Nationwide Inpatient Sample from the years 2000 to 2007 found the frequency of hospitalizations for adults aged ≥18 years with a hypertensive emergency increased from 101 to 111 per 100 000 in 2007 (average increase of 1.11%). In contrast to the increased number of hospitalizations, the all-cause in-hospital mortality rate decreased during the same period from 2.8% to 2.6%.[60]
- Data from ambulatory medical care use estimates for 2010 showed that the number of visits for essential hypertension was 43 436 000. Of these, 38 916 000 were physician office visits, 940 000 were ED visits, and 3 580 000 were outpatient department visits (NAMCS and NHAMCS, NHLBI tabulation).
- In 2012, there were 34 016 000 physician office visits for a primary diagnosis of essential hypertension (*ICD-9-CM* 401) (NCHS, NAMCS, NHLBI tabulation). In 2011, there were 968 000 ED visits and 3 743 000 outpatient department visits for essential hypertension (NCHS, NHAMCS, NHLBI tabulation).

Awareness, Treatment, and Control

(See Table 9-2 and Charts 9-3 through 9-5.)

- Data from NHANES 2009 to 2012 showed that of those with hypertension who were ≥20 years of age, 82.7% were aware of their condition, 76.5% were under current treatment, 54.1% had their hypertension under control, and 45.9% did not have it controlled. Awareness and treatment of hypertension were higher at older ages. Hypertension control was higher in US adults 40 to 59 years of age (58.0%) and those ≥60 years of age (54.1%) than in their counterparts 20 to 39 years of age (35.4%). Non-Hispanic black adults were more aware of their hypertension than Hispanics (87.0% and 77.7%, respectively; NHLBI tabulation).
- Data from NHANES 1999 to 2008 and BRFSS 1997 to 2009 showed awareness, treatment, and control of hypertension varied across the country and were highest in the southeastern United States.[61]
- Analysis of NHANES 1999 to 2006 and 2009 to 2012 found the proportion of adults aware of their hypertension increased within each race/ethnicity and sex subgroup. Similarly, large increases in hypertension treatment and control (≈10%) occurred in each of these groups (Table 9-2).
- According to data from NHANES 2003 to 2004 through 2011 to 2012, HBP control rates improved from 39.4% to 51.8%. Awareness increased from 75.2% to 82.1%, and treatment improved from 65.0% to 74.5%.[62]
- Among US adults taking prescription antihypertensive medication, the age-adjusted percentage with BP control improved from 61.9% to 70.4%.[62]
- In 2011 to 2012, medication use to lower hypertension was lowest for those aged 18 to 39 years (44.5%) compared with those aged 40 to 59 years (73.7%) and those aged ≥60 years (82.2%). Non-Hispanic black adults were more likely to take antihypertensive medication than non-Hispanic white, Hispanic, or Asian adults (77.4%, 76.7%, 73.5%, and 65.2% respectively).[4]
- Data from NHANES 2005 to 2010 show that among those ≥80 years of age, 79.4% of those with hypertension were aware of this condition, 57.4% were treated, and 39.8% had controlled their BP to JNC 7 targets.[16]
- The change in SBP threshold from JNC 7 to the 2014 *JAMA* definition resulted in 5.8 million fewer US adults having antihypertensive medication treatment recommended to them, and 13.5 million fewer US adults taking treatment were recommended to be prescribed dose intensification or additional medication classes.[10]
- Among a cohort of postmenopausal women taking hormone replacement, hypertension was the most common comorbidity, with a prevalence of 34%.[63]
- In 2005, a survey of people in 20 states conducted by the BRFSS of the CDC found that 19.4% of respondents had been told on ≥2 visits to a health professional that they had HBP. Of these, 70.9% reported changing their eating habits; 79.5% reduced the use of or were not using salt; 79.2% reduced the use of or eliminated alcohol; 68.8% were exercising; and 73.4% were taking antihypertensive medication.[64]
- Among 1509 NHANES 2005 to 2006 participants aged ≥30 years with hypertension, 24% were categorized as low risk, 21% as intermediate risk, and 23% as high risk according to Framingham global risk. Treatment for hypertension varied by risk category and ranged from 58% to 75%; hypertension control was 80% for those in the low-risk category and <50% for those in the high-risk category.[65]
- According to data from NHANES 2001 to 2006, non-Hispanic blacks had 90% higher odds of poorly controlled BP than non-Hispanic whites. Among those who were hypertensive, non-Hispanic blacks and Mexican Americans had 40% higher odds of uncontrolled BP than non-Hispanic whites.[66]
- According to data from NHANES 1998 to 2008 for adults with DM, prevalence of hypertension increased, whereas

awareness, treatment, and control improved during these time periods; however, for adults 20 to 44 years of age, there was no evidence of improvement.[67]

Cost

(See Table 9-1.)

- The estimated direct and indirect cost of HBP for 2011 to 2012 (annual average) was $48.6 billion (MEPS, NHLBI tabulation).
- Controlling hypertension in all patients with CVD or stage 2 hypertension could be effective and cost-saving.[68]
- Projections show that by 2030, the total cost of HBP could increase to an estimated $274 billion (unpublished AHA computation, based on methodology described in Heidenreich et al[12]).

Global Burden of Hypertension

- In 2000, it was estimated that 972 million adults worldwide had hypertension[69]
- Between 1980 and 2008[70]:
  - —The global mean age-adjusted SBP declined from 130.5 mm Hg in 1980 to 128.1 mm Hg in men and from 127.2 to 124.4 mm Hg in women.
  - —The global age-adjusted prevalence of uncontrolled hypertension decreased from 33% to 29% among men and from 29% to 25% among women.
  - —Because of population growth and aging, the number of people worldwide with uncontrolled hypertension (SBP ≥140 mm Hg or DBP ≥90 mm Hg) increased from 605 million to 978 million between 1980 and 2008.[70]
- HBP went from being the fourth-leading risk factor in 1990, as quantified by DALYs, to being the number 1 risk factor in 2010.[71]
- In 2010, HBP was 1 of the 5 leading risk factors in all regions with the exception of Oceania, Eastern sub-Saharan Africa, and Western sub-Saharan Africa.[71]

Prehypertension

- Prehypertension is untreated SBP of 120 to 139 mm Hg or untreated DBP of 80 to 89 mm Hg and not having been told on 2 occasions by a physician or other health professional that one has hypertension.
- Among participants without a history of CVD or cancer in NHANES 1999 to 2006, the prevalence of prehypertension was 36.3%. Prevalence was higher in men than in women. Furthermore, prehypertension was correlated with an adverse cardiometabolic risk profile.[72]
- Follow-up of 9845 men and women in the FHS/NHLBI who attended examinations from 1978 to 1994 revealed that at 35 to 64 years of age, the 4-year incidence of hypertension was 5.3% for those with baseline BP <120/80 mm Hg, 17.6% for those with SBP of 120 to 129 mm Hg or DBP of 80 to 84 mm Hg, and 37.3% for those with SBP of 130 to 139 mm Hg or DBP of 85 to 89 mm Hg. At 65 to 94 years of age, the 4-year incidences of hypertension were 16.0%, 25.5%, and 49.5% for these BP categories, respectively.[73]Among participants with and without prehypertension in MESA, 23.6% and 5.3%, respectively, developed hypertension over 4.8 years of follow-up.[56]Among young adults (18 to 30 years at baseline) with and without prehypertension in CARDIA, 23.1% and 3.8%, respectively, developed hypertension over 5 years of follow-up.[57]Data from FHS/NHLBI also reveal that prehypertension is associated with elevated relative and absolute risks for CVD outcomes across the age spectrum. Compared with normal BP (<120/80 mm Hg), prehypertension was associated with a 1.5- to 2-fold increased risk for major CVD events in those <60, 60 to 79, and ≥80 years of age. Absolute risks for major CVD associated with prehypertension increased markedly with age: 6-year event rates for major CVD were 1.5% in prehypertensive people <60 years of age, 4.9% in those 60 to 79 years of age, and 19.8% in those ≥80 years of age.[74]In the REGARDS study, prehypertension was more common in blacks than whites and was more common among people with other risk factors, including DM and elevated CRP.[75]A meta-analysis of 29 prospective cohort studies (including 1 010 858 participants) found prehypertension was associated with CVD incidence or death, stroke, and MI. The risk was particularly noted for those with BP values in the higher prehypertension range.[76]A separate meta-analysis of 17 prospective cohort studies (n=591 664) reported prehypertension to be associated with an increased risk for CHD (RR, 1.43; 95% CI, 1.26–1.63). This association and the PAR for CHD was stronger in Western than in Asian populations.[77]Two randomized controlled trials have reported that pharmacological treatment of hypertension is associated with a lower incidence of hypertension.[78,79]

Table 9-1. High Blood Pressure

Population Group	Prevalence, 2012, Age ≥20 y	Mortality,* 2013, All Ages	Hospital Discharges, 2010, All Ages	Estimated Cost, 2012
Both sexes	80 000 000 (32.6%)	71 942	488 000	$48.6 Billion
Males	38 300 000 (33.5%)	33 563 (46.7%)†	216 000	…
Females	41 700 000 (31.7%)	38 379 (53.3%)†	272 000	…
NH white males	32.9%	22 392	…	…
NH white females	30.1%	27 446	…	…
NH black males	44.9%	7344	…	…
NH black females	46.1%	7230	…	…
Hispanic males	29.6%	2546	…	…
Hispanic females	29.9%	2362	…	…
NH Asian or Pacific Islander	…	1875‡	…	…
NH American Indian/Alaska Native	26.4%§	420	…	…

Hypertension is defined in terms of National Health and Nutrition Examination Survey blood pressure measurements and health interviews. A subject was considered hypertensive if systolic blood pressure was ≥140 mm Hg or diastolic blood pressure was ≥90 mm Hg, if the subject said "yes" to taking antihypertensive medication, or if the subject was told on 2 occasions that he or she had hypertension. Prevalence in American Indian or Alaska Natives is based on self-report data from the National Health Interview Survey, with hypertension defined as subjects having been told on ≥2 different visits that they had hypertension or high blood pressure. Ellipses (…) indicate data not available; and NH, non-Hispanic.

*Mortality for Hispanic, American Indian or Alaska Native, and Asian and Pacific Islander people should be interpreted with caution because of inconsistencies in reporting Hispanic origin or race on the death certificate compared with censuses, surveys, and birth certificates. Studies have shown underreporting on death certificates of American Indian or Alaska Native, Asian and Pacific Islander, and Hispanic decedents, as well as undercounts of these groups in censuses.

†These percentages represent the portion of total high blood pressure mortality that is for males vs females.

‡Includes Chinese, Filipino, Hawaiian, Japanese, and other Asian or Pacific Islander.

§National Health Interview Survey (2014), National Center for Health Statistics; data are weighted percentages for Americans ≥18 years of age. Individuals had to have been told on ≥2 different visits that they had hypertension or high blood pressure to be classified as hypertensive.[37]

Sources: Prevalence: National Health and Nutrition Examination Survey (2009–2012), National Center for Health Statistics, and National Heart, Lung, and Blood Institute. Percentages for racial/ethnic groups are age adjusted for Americans ≥20 years of age. Age-specific percentages are extrapolated to the 2012 US population estimates. Mortality: Centers for Disease Control and Prevention/National Center for Health Statistics, 2013 Mortality Multiple Cause-of-Death–United States. These data represent underlying cause of death only. Hospital discharges: National Hospital Discharge Survey, National Center for Health Statistics; data include those discharged alive, dead, or status unknown. Cost: Medical Expenditure Panel Survey data include estimated direct costs for 2011 to 2012 (annual average); indirect costs calculated by National Heart, Lung, and Blood Institute for 2011 to 2012 (annual average).

Table 9-2. Hypertension Awareness, Treatment, and Control: NHANES 1999 to 2006 and 2007 to 2012, by Race/Ethnicity and Sex

	Awareness		Treatment		Control	
	1999–2006	2007–2012	1999–2006	2007–2012	1999–2006	2007–2012
NH white males	71.8	80.2	61.8	72.6	41.9	53.3
NH white females	76.9	84.4	68.1	80.2	40.0	56.7
NH black male	70.1	80.0	59.6	67.9	34.1	40.7
NH black females	85.3	88.2	76.6	81.1	43.8	54.1
Mexican American males	57.7	67.0	41.8	57.9	25.6	35.0
Mexican American females	69.9	78.6	57.9	70.5	31.9	47.0

Values are percentages. Hypertension is defined in terms of NHANES blood pressure measurements and health interviews. A subject was considered hypertensive if systolic blood pressure was ≥140 mm Hg or diastolic blood pressure was ≥90 mm Hg, or if the subject said "yes" to taking antihypertensive medication. NH indicates non-Hispanic; and NHANES, National Health and Nutrition Examination Survey.

Sources: NHANES (1999–2006, 2007–2012) and National Heart, Lung, and Blood Institute.

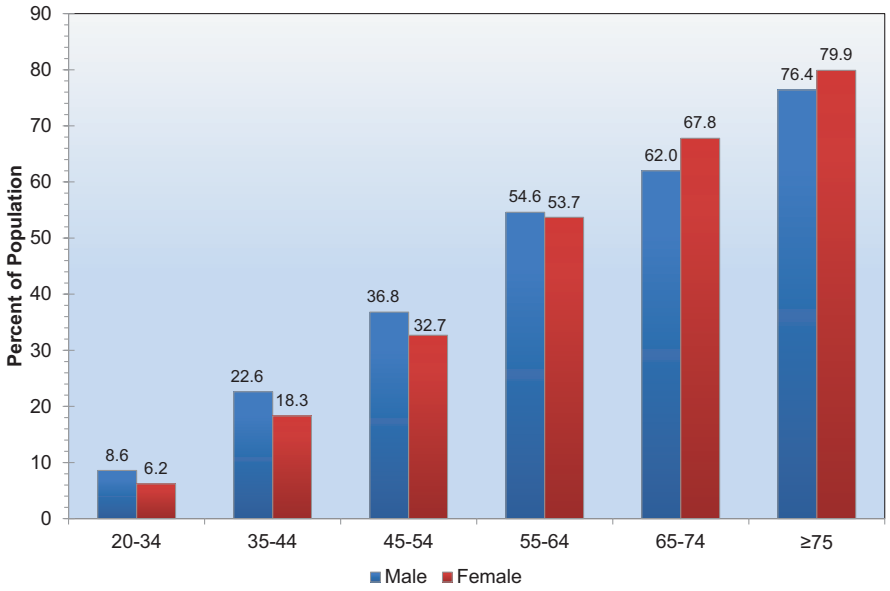

Chart 9-1. Prevalence of high blood pressure in adults ≥20 years of age by age and sex (National Health and Nutrition Examination Survey: 2007–2012). Hypertension is defined as systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg, if the subject said "yes" to taking antihypertensive medication, or if the subject was told on 2 occasions that he or she had hypertension. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

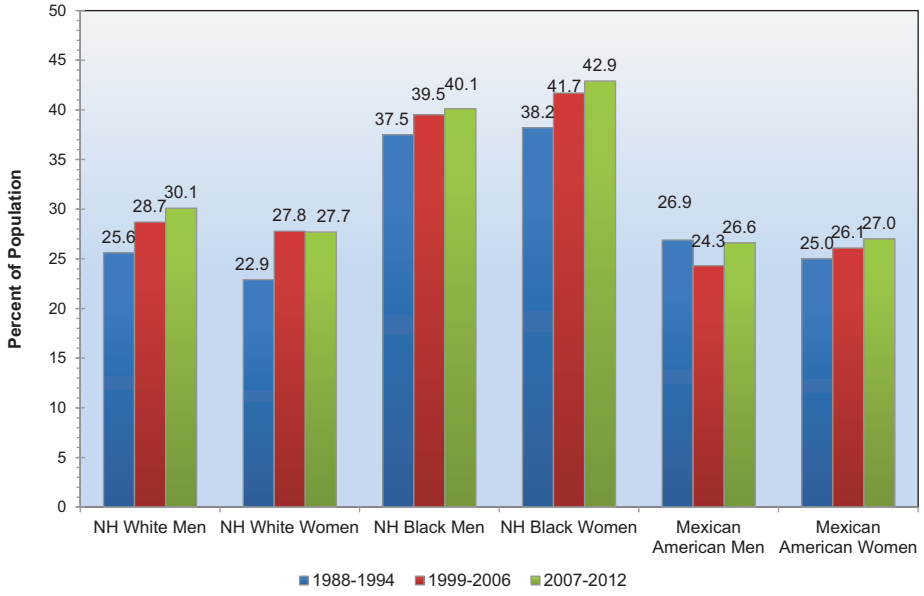

Chart 9-2. Age-adjusted prevalence trends for high blood pressure in adults ≥20 years of age by race/ethnicity, sex, and survey (National Health and Nutrition Examination Survey: 1988–1994, 1999–2006, and 2007–2012). Hypertension is defined as systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg, if the subject said "yes" to taking antihypertensive medication, or if the subject was told on 2 occasions that he or she had hypertension. NH indicates non-Hispanic. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

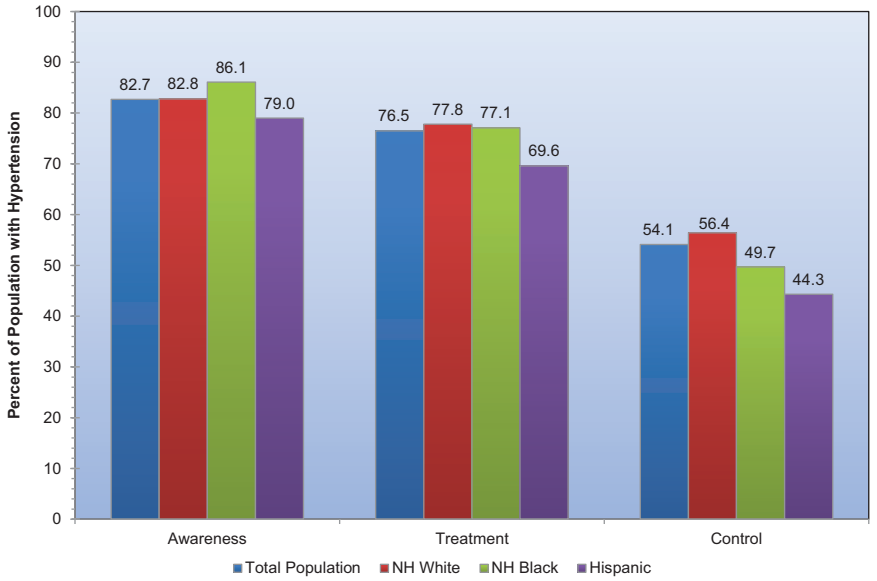

Chart 9-3. Extent of awareness, treatment, and control of high blood pressure by race/ethnicity (National Health and Nutrition Examination Survey: 2007–2012). Hypertension is defined as systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg, or if the subject said "yes" to taking antihypertensive medication. NH indicates non-Hispanic. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

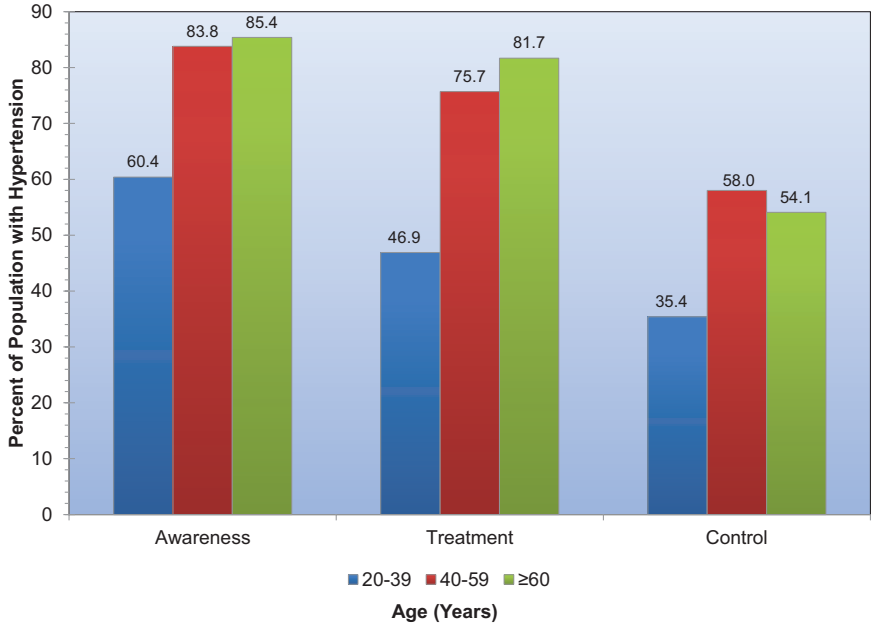

Chart 9-4. Extent of awareness, treatment, and control of high blood pressure by age (National Health and Nutrition Examination Survey: 2007–2012). Hypertension is defined as systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg, or if the subject said "yes" to taking antihypertensive medication. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

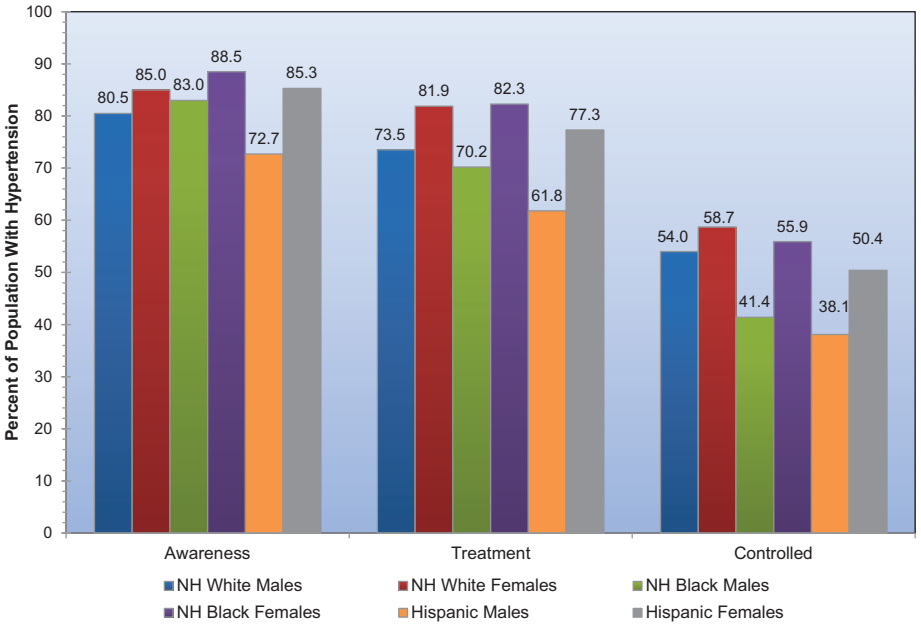

Chart 9-5. Extent of awareness, treatment, and control of high blood pressure by race/ethnicity and sex (National Health and Nutrition Examination Survey: 2007–2012). Hypertension is defined as systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg, or if the subject said "yes" to taking antihypertensive medication. NH indicates non-Hispanic. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

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10. Diabetes Mellitus

ICD-9 250; ICD-10 E10 to E14. See Table 10-1 and Charts 10-1 through 10-6.

DM is a major risk factor for CVD, such as CHD, stroke, PAD, HF and AF.[1] The AHA has identified untreated fasting blood glucose levels of <100 mg/dL for children and adults as 1 of the 7 components of ideal cardiovascular health.[2] In 2011 to 2012, 85.3% of children and 56.5% of adults met these criteria.

Prevalence

Youth

- Approximately 186 000 people <20 years of age have DM. Each year, ≈15 000 people <20 years of age are diagnosed with type 1 DM. Healthcare providers are finding more and more children with type 2 DM, a disease usually diagnosed in adults ≥40 years of age. Children who develop type 2 DM are typically overweight or obese and have a family history of the disease, with incidence rates among American Indian, black, Asian, and Hispanic/Latino children 3- to 8-fold higher than in non-Hispanic whites.[3]
- Between 2001 and 2009, the prevalence of type 2 DM in youths increased by 30.5%.[4]
- Among adolescents 10 to 19 years of age diagnosed with DM, 57.8% of blacks were diagnosed with type 2 versus type 1 DM compared with 46.1% of Hispanic youths and 14.9% of white youths.[3]
- According to the Bogalusa Heart Study, a long-term follow-up study of youths aging into adulthood, youths who were prediabetic or who had DM were more likely to have a constellation of metabolic disorders in young adulthood (19–44 years of age), including obesity, hypertension, dyslipidemia, and metabolic syndrome, all of which predispose to CHD.[5]
- Among youths with type 2 DM, 10.4% are overweight and 79.4% are obese.[6]
- According to NHANES data from 1999 to 2007, among US adolescents aged 12 to 19 years, the prevalence of prediabetes and DM increased from 9% to 23%.[7]

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Abbreviations Used in Chapter 10

ACC	American College of Cardiology
ACS	acute coronary syndrome
ADVANCE	Action in Diabetes and Vascular Disease: Preterax and Diamicron Modified Release Controlled Evaluation
AF	atrial fibrillation
AHA	American Heart Association
AHRQ	Agency for Healthcare Research and Quality
AMI	acute myocardial infarction
ARIC	Atherosclerosis Risk in Communities
BMI	body mass index
BP	blood pressure
BRFSS	Behavioral Risk Factor Surveillance System
CDC	Centers for Disease Control and Prevention
CHD	coronary heart disease
CHS	Cardiovascular Health Study
CI	confidence interval
CVD	cardiovascular disease
DCCT	Diabetes Control and Complications Trial
DM	diabetes mellitus
ED	emergency department
EDIC	Epidemiology of Diabetes Interventions and Complications Study
ESRD	end-stage renal disease
EVEREST	Efficacy of Vasopressin Antagonism in Heart Failure Outcome Study With Tolvaptan
FHS	Framingham Heart Study
HbA_{1c}	hemoglobin A_{1c}
HCHS/SOL	Hispanic Community Health Study/Study of Latinos
HD	heart disease
HF	heart failure
HR	hazard ratio
ICD-9	*International Classification of Diseases, 9th Revision*
ICD-10	*International Classification of Diseases, 10th Revision*
IDDM	insulin-dependent diabetes mellitus
LDL-C	low-density lipoprotein cholesterol
MESA	Multi-Ethnic Study of Atherosclerosis
MI	myocardial infarction
NCHS	National Center for Health Statistics
NH	non-Hispanic
NHANES	National Health and Nutrition Examination Survey
NHDS	National Hospital Discharge Survey
NHIS	National Health Interview Survey
NHLBI	National Heart, Lung, and Blood Institute
NRMI	National Registry of Myocardial Infarction
NSTEMI	non–ST-segment–elevation myocardial infarction
OR	odds ratio
PA	physical activity
PAD	peripheral artery disease
PAR	population attributable risk
RR	relative risk
SBP	systolic blood pressure
SEARCH	Search for Diabetes in Youth Study
STEMI	ST-segment–elevation myocardial infarction
TC	total cholesterol
TIMI	Thrombolysis in Myocardial Infarction
TODAY	Treatment Options for Type 2 Diabetes in Adolescents and Youth
TRIUMPH	Translational Research Investigating Underlying Disparities in Acute Myocardial Infarction Patients' Health Status
UA	unstable angina

- Analyses of a cohort of consecutive high school blood donors in north Texas from September 2011 to March 2012 comprising 14 850 adolescents showed that 10.0% had HbA_{1c} values in the prediabetes range (HbA_{1c} 5.7%–6.4%), and an additional 0.6% had HbA_{1c} ≥6.5%, the threshold endorsed to diagnose DM.[8]
- The results of the TODAY study demonstrated that only half of the children (41.1% Hispanic and 31.5% non-Hispanic black) maintained durable glycemic control with monotherapy,[9] a higher rate of treatment failure than observed in adult cohorts. Youths who had type 2 DM were sedentary >56 minutes longer per day (via accelerometry) than obese youths from NHANES.[10]

Adults

(See Table 10-1 and Charts 10-1 through 10-4.)

- On the basis of data from NHANES 2009 to 2012 (unpublished NHLBI tabulation), an estimated 21.1 million adults have diagnosed DM, 8.1 million adults have undiagnosed DM, and 80.8 million adults (35.3%) have prediabetes (eg, fasting blood glucose of 100 to <126 mg/dL).
- Type 2 DM accounts for 90% to 95% of all diagnosed cases of DM in adults.[11]
- Analysis of NHANES/NCHS data from 1988 to 1994 and from 2005 to 2010 in adults ≥20 years of age showed that the prevalence of DM (diagnosed DM or HbA_{1c} ≥6.5%) among adults ≥20 years of age increased from 6.2% in 1988 to 1994 to 9.9% (21 million adults) in 2005 to 2010.[12]
- Minority groups remain disproportionately affected by DM.[12] The prevalence of total DM (diagnosed DM or HbA_{1c} ≥6.5%) in non-Hispanic blacks is almost twice as high as in whites (15.4% versus 8.6%), and Mexican Americans had a 35% higher prevalence of DM than whites (11.6% versus 8.6%).[12]
- The prevalence of diagnosed DM in adults ≥65 years of age was 26.9% in 2010, and an additional 50% (>20 million) had prediabetes based on fasting glucose, oral glucose tolerance testing, or HbA_{1c}. In addition, data from NHANES 2005 to 2006 show that 46% of DM cases remain undiagnosed in this group aged ≥65 years.[13]
- According to the Bogalusa Heart Study, men >20 years of age have a slightly higher prevalence of DM (11.8%) than women (10.8%).[3]
- After adjustment for population age differences, 2010 to 2012 national survey data for people >20 years of age indicate that 7.6% of non-Hispanic whites, 9.0% of Asian Americans, 12.8% of Hispanics, 13.2% of non-Hispanic blacks, and 15.9% of American Indians/Alaska Natives had diagnosed DM.[11]
- Compared with non-Hispanic white adults, the risk of diagnosed DM was 18% higher among Asian Americans, 66% higher among Hispanics/Latinos, and 77% higher among non-Hispanic blacks.[14]
- In the prospective, multicenter, population-based HCHS/SOL, 16 415 adults of Hispanic/Latino descent aged 18 to 74 years were enrolled from 4 US metropolitan areas from 2008 to 2011. The prevalence of DM was considerably diverse across adults with different Hispanic backgrounds. DM prevalence ranged from 10.2% in South Americans to 13.4% in Cubans, 17.7% in Central Americans, 18.0% in Dominicans and Puerto Ricans, and 18.3% in Mexicans.[15]
- On the basis of 2013 BRFSS (CDC) data, the prevalence of adults in the United States who reported ever having been told by a physician that they had DM ranged from 6.2% in Colorado to 12.6% in Alabama. The mean percentage among all states was 9.4%.[16]
- On the basis of projections from NHANES studies between 1984 and 2004, the total prevalence of DM in the United States is expected to more than double from 2005 to 2050 (from 5.6% to 12.0%) in all age, sex, and race/ethnicity groups. Increases are projected to be largest for the oldest age groups (for instance, projected to increase by 220% among those 65–74 years of age and by 449% among those ≥75 years of age). DM prevalence is projected to increase by 99% among non-Hispanic whites, by 107% among non-Hispanic blacks, and by 127% among Hispanics. The age/race/ethnicity group with the largest increase is expected to be blacks ≥75 years of age (projected increase of 606%).[17]

Incidence

Youth

- During 2008 to 2009, an estimated 18 436 people <20 years of age in the United States were newly diagnosed with type 1 DM annually, and 5089 individuals <20 years old were newly diagnosed with type 2 DM annually.[11]
- In the SEARCH study, the incidence of DM in youths overall was 24.3 per 100 000 person-years. Of 2291 individuals <20 years of age with newly diagnosed DM, slightly more than half (54.5%) had autoimmune, insulin-sensitive DM, and 15.9% had nonautoimmune, insulin-resistant DM.[18] The highest rates of incident type 1 DM were observed in non-Hispanic white youths (18.6, 28.1, and 32.9 per 100 000 person-years for age groups of 0–4, 5–9, and 10–14 years, respectively). Overall, type 2 DM was relatively infrequent among youths, with the highest rates (17.0–49.4 per 100 000 person-years) seen among 15- to 19-year-old minority groups.[3]
- Projecting disease burden for the US population <20 years of age by 2050, the number of youths with type 1 DM will conservatively increase from 166 018 to 203 382, and the number with type 2 DM will increase from 20 203 to 30 111. Less conservative modeling projects the number of youths with type 1 DM at 587 488 and those with type 2 DM at 84 131 by 2050.[19]

Adults

(See Table 10-1.)

- A total of 1.7 million new cases of DM (type 1 or type 2) were diagnosed in US adults ≥20 years of age in 2012.[11]
- Data from the FHS indicate a doubling in the incidence of DM over the past 30 years, most dramatically during the 1990s. Among adults 40 to 55 years of age in each decade of the 1970s, 1980s, and 1990s, the age-adjusted 8-year incidence rates of DM were 2.0%, 3.0%, and 3.7% among women and 2.7%, 3.6%, and 5.8% among men, respectively. Compared with the 1970s, the age-and sex-adjusted

OR for DM was 1.40 in the 1980s and 2.05 in the 1990s (*P* for trend=0.0006). Most of the increase in absolute incidence of DM occurred in individuals with a BMI ≥30 kg/m^2 (*P* for trend=0.03).[20]

- DM incidence in adults also varies markedly by race. Over 5 years of follow-up in 45- to 84-year-olds in MESA, 8.2% of the cohort developed DM. The cumulative incidence was highest in Hispanics (11.3%), followed by black (9.5%), Chinese (7.7%), and white (6.3%) participants.[21]
- According to NHANES data from 1988 to 1994 compared with 2005 to 2010, the prevalence of DM increased from 8.4% to 12.1%. This increase was most pronounced among those ≥65 years of age (increase in prevalence from 18.6% to 28.5%).[22]
- Of 15.4 million people being treated with glucose-lowering medication (86.6% of the diagnosed diabetic population), 8.5 million (55.2%) had their hyperglycemia under control (ie, had calibrated HbA_{1c} <7%), and 6.9 million (44.8%) were being treated but had HbA_{1c} ≥7%. An estimated 2.4 million individuals with diagnosed DM are not treated with glucose-lowering therapy.[12]
- According to data from NHANES and BRFSS, up to 48.7% of individuals with self-reported DM did not meet glycemic, BP, and lipid targets, and only 14.3% met all 3 targets and did not smoke.[23]
- Gestational DM complicates 2% to 10% of pregnancies and increases the risk of developing type 2 DM by 35% to 60%.[14]

Mortality

(See Table 10-1.)

- DM mortality in 2013 was 75 578. Any-mention mortality in 2013 was 246 804.[24]
- The 2013 overall underlying-cause death rate attributable to DM was 21.2. Death rates per 100 000 population were 23.1 for non-Hispanic white males, 45.1 for non-Hispanic black males, 30.4 for Hispanic males, 14.9 for non-Hispanic white females, 35.2 for non-Hispanic black females, and 23.0 for Hispanic females.[24]
- According to data from the CDC, the National Diabetes Information Clearinghouse, the National Institute of Diabetes and Digestive and Kidney Diseases, and the National Institutes of Health:
  - —At least 68% of people >65 years of age with DM die of some form of HD; 16% die of stroke.
  - —HD death rates among adults with DM are 2 to 4 times higher than the rates for adults without DM.[14]
- In a collaborative meta-analysis of 820 900 individuals from 97 prospective studies, DM was associated with the following risks: all-cause mortality (HR, 1.80; 95% CI, 1.71–1.90); cancer death (HR, 1.25; 95% CI, 1.19–1.31); and vascular death (HR, 2.32; 95% CI, 2.11–2.56). In particular, DM was associated with death attributable to the following cancers: liver, pancreas, ovary, colorectal, lung, bladder, and breast. A 50-year-old with DM died on average 6 years earlier than an individual without DM.[25]
- FHS/NHLBI data showed that having DM significantly increased the risk of developing CVD (HR 2.5 for women and 2.4 for men) and of dying when CVD was present (HR 2.2 for women and 1.7 for men). Men and women ≥50 years of age with DM lived an average of 7.5 and 8.2 years less than their counterparts without DM. The differences in life expectancy free of CVD were 7.8 and 8.4 years, respectively.[26]
- Analysis of data from the FHS from 1950 to 2005 found reductions in all-cause and CVD mortality among men and women with and without DM; however, all-cause and CVD mortality rates among individuals with DM remain ≈2-fold higher than for individuals without DM.[27]
- Among individuals ≥65 years of age participating in the CHS, during follow-up for up to 16 years, adjusted CHD mortality risk was similar for those with prevalent CHD free of DM at study entry compared with participants with DM but free of CHD (HR, 1.04; 95% CI, 0.83–1.30).[28]
- According to NHIS data from 1997 to 2006, the rate of CVD death among adults with DM decreased by 40% (95% CI, 23%–54%). Similarly, all-cause mortality decreased by 23% (95% CI, 10%–35%). In contrast, over this same period among adults without DM, the CVD mortality rate decreased by 60%, and the all-cause mortality rate decreased by 44%.[29]

Awareness

(See Chart 10-5.)

- Analysis of NHANES data collected during 2005 to 2010 indicated that the prevalence of diagnosed DM, defined as people told by a physician or other health professional that they had DM, was 8.4% among people ≥20 years of age.[12]
- Although the prevalence of diagnosed DM has increased significantly over the past decade, the numbers of adults with undiagnosed DM and impaired fasting glucose has remained relatively stable. Of the estimated 21 million adults with DM, 84.8% were told they had DM or were undergoing treatment, and 11% (2.3 million) of those with confirmed DM (calibrated HbA_{1c} level ≥6.5% and fasting plasma glucose level ≥126 mg/dL) were unaware of the diagnosis.[12] In the HCHS/SOL population-based study of adults of Hispanic/Latino descent, only 58.7% of participants with DM were aware of their diagnosis.[15]
- The prevalence of undiagnosed DM among MI patients was assessed with data from the TRIUMPH US multicenter AMI registry with data collection from 2005 to 2008. This study revealed that DM that had not been previously diagnosed affected 1 in 10 patients based on research core laboratory testing of HbA_{1c}, yet DM was diagnosed by the care team only one third of the time. The authors endorsed consideration of DM screening by HbA_{1c} measurement for all MI patients without prior DM diagnosis.[30]

Aftermath

(See Chart 10-6.)

- Although the exact date of DM onset can be difficult to determine, increasing duration of DM diagnosis is

associated with increasing CVD risk. Longitudinal data from the FHS suggest that the risk factor–adjusted RR of CHD is 1.38 (95% CI, 0.99–1.92) times higher and the risk for CHD death is 1.86 (95% CI, 1.17–2.93) times higher for each 10-year increase in duration of DM.[31]

- On the basis of data from the NCHS/NHIS, 1997 to 2005[32]:
  - —The estimated number of people ≥35 years of age with DM with a self-reported cardiovascular condition increased 36%, from 4.2 million in 1997 to 5.7 million in 2005; however, the respective age-adjusted prevalence decreased 11.2%, from 36.6% in 1997 to 32.5% in 2005, which reflects an increase in the number of patients diagnosed with DM that exceeded the increase in CVD prevalence.
  - —Age-adjusted CVD prevalence was higher among men than among women, among whites than among blacks, and among non-Hispanics than among Hispanics. Among women, the age-adjusted prevalence decreased by 11.2%; among men, it did not decrease significantly. Among blacks, the age-adjusted prevalence of self-reported CVD decreased by 25.3%; among whites, no significant decrease occurred; among non-Hispanics, the rate decreased by 12%. No clear trends were detected among Hispanics.
  - —Because the total number of people with DM and self-reported CVD increased over this period but proportions with self-reported CVD declined, the data suggest that the mean age at which people are diagnosed with DM is decreasing, or the higher CVD mortality rate among older individuals with DM is removing them from the ability to self-report CVD. These and other data show a consistent increase over time in the United States of the number of people with DM and CVD.
- Data from the FHS show that despite improvements in CVD morbidity and mortality over >4 decades of observation, DM continues to be associated with incremental CVD risk. Participants 45 to 64 years of age from the FHS original and offspring cohorts who attended examinations in 1950 to 1966 ("earlier" time period) and in 1977 to 1995 ("later" time period) were followed up for incident MI, CHD death, and stroke. Among participants with DM, the age- and sex-adjusted CVD incidence rate was 286.4 per 10 000 person-years in the earlier period and 146.9 per 10 000 person-years in the later period, a 35.4% decline. HRs for DM as a predictor of incident CVD were not significantly different in the earlier (risk factor–adjusted HR, 2.68; 95% CI, 1.88–3.82) versus later (HR, 1.96; 95% CI, 1.44–2.66) period. Thus, although there was a 50% reduction in the rate of incident CVD events among adults with DM, the absolute risk of CVD remained 2-fold greater than among people without DM.[33]
  - —Data from these earlier and later time periods in the FHS also suggest that the increasing prevalence of DM is leading to an increasing rate of CVD, resulting in part from CVD risk factors that commonly accompany DM. The age- and sex-adjusted HR for DM as a CVD risk factor was 3.0 in the earlier time period and 2.5 in the later time period. Because the prevalence of DM has increased over time, the PAR for DM as a CVD risk factor increased from 5.4% in the earlier time period to 8.7% in the later time period (attributable risk ratio, 1.62; P=0.04). Adjustment for CVD risk factors (age, sex, hypertension, current smoking, high cholesterol, and obesity) weakened this attributable risk ratio to 1.5 (P=0.12).[34]
  - —Other data from the FHS show that over a 30-year period, CVD among women with DM was 54.8% among normal-weight women but 78.8% among obese women. Among normal-weight men with DM, the lifetime risk of CVD was 78.6%, whereas it was 86.9% among obese men.[35]
- In analyses from the NRMI comprising data registered on 1 734 431 patients admitted with AMI to 1964 participating US hospitals, the incremental adjusted OR for hospital mortality associated with DM declined from 1.24 (95% CI, 1.16–1.32) in 1994 to 1.08 (95% CI, 0.99–1.19) in 2006, which demonstrates a closing of the acute hospital mortality gap associated with DM.[36]
- On the basis of analyses of data from the NHIS, the NHDS, the US Renal Data System, and the US National Vital Statistics System, between 1990 and 2010, the rate of incident MI among patients with DM declined 67.8% (Chart 10-6).[37]
- A subgroup analysis was conducted of patients with DM enrolled in randomized clinical trials that evaluated ACS therapies. The data included 62 036 patients from TIMI studies (46 577 with STEMI and 15 459 with UA/NSTEMI). Of these, 17.1% had DM. Modeling showed that mortality at 30 days was significantly higher among patients with DM than among those without DM who presented with UA/NSTEMI (2.1% versus 1.1%; P≤0.001) and STEMI (8.5% versus 5.4%; P=0.001), with adjusted risks for 30-day mortality in DM versus no DM of 1.78 for UA/NSTEMI (95% CI, 1.24–2.56) and 1.40 (95% CI, 1.24–1.57) for STEMI. DM was also associated with significantly higher mortality 1 year after UA/NSTEMI or STEMI. By 1 year after ACS, patients with DM who presented with UA/NSTEMI had a risk of death that approached that of patients without DM who presented with STEMI (7.2% versus 8.1%).[38]
- DM increases the risk of HF and adversely affects outcomes among patients with HF.
  - —DM alone qualifies for the most recent ACC Foundation/AHA diagnostic criteria for stages A and B HF, a classification of patients without HF but at notably high risk for its development.[39]
  - —In MESA, DM was associated with a 2-fold increased adjusted risk of incident HF among 6814 individuals free of CVD at baseline over a mean follow-up of 4 years (HR, 1.99; 95% CI, 1.08–3.68).[40]
  - —Post hoc analysis of data from the EVEREST randomized trial of patients hospitalized with decompensated systolic HF stratified by DM status, which evaluated cardiovascular outcomes over a follow-up period of 9.9 months, demonstrated an increased adjusted HR for the composite of cardiovascular mortality and HF rehospitalization associated with DM (HR, 1.17; 95% CI, 1.04–1.31).[41]
- DM increases the risk of AF. On the basis of meta-analysis of published observational data comprising 11 studies and >1.6 million participants, DM was crudely associated with

a 40% increased risk for AF (RR, 1.39; 95% CI, 1.10–1.75), with the association remaining significant after multivariable adjustment (adjusted RR, 1.24; 95% CI, 1.06–1.44), yielding an estimate of the population attributable fraction of AF attributable to DM of 2.5%.[42]

- DM increases the risk of stroke, with the RR ranging from 1.8- to 6-fold increased risk.[31,43]
  - —DM is associated with increased ischemic stroke incidence at all ages, with the incremental risk associated with DM being most prominent before 55 years of age in blacks and before 65 years of age in whites.[43]
  - —Ischemic stroke patients with DM are younger, more likely to be black, and more likely to have hypertension, prior MI, and high cholesterol than patients without DM.[43]
- On the basis of analyses of data from the NHIS, the NHDS, the US Renal Data System, and the US National Vital Statistics System, between 1990 and 2010, the rate of incident stroke among patients with DM declined 52.7% (Chart 10-6).[37]
- DM accounted for 44% of the new cases of ESRD in 2011.[44]
- In 2012, the incidence rate of ESRD attributed to DM in adults ≥20 years in the Veterans Affairs health system increased with age, from 4.44 per 100 000 in those aged 20 to 29 years to 110.35 per 100 000 in those ≥70 years old, compared with rates of 2.40 and 81.88, respectively, in those without DM.[45]
- On the basis of analyses of data from the NHIS, the NHDS, the US Renal Data System, and the US National Vital Statistics System, between 1990 and 2010, the rate of incident ESRD among patients with DM declined 28.3% (Chart 10-6).[37]
- HbA_{1c} levels ≥6.5% can be used to diagnose DM.[46] In the population-based ARIC study, over a 14-year follow-up period that preceded the endorsement of HbA_{1c} as a diagnostic criterion, HbA_{1c} levels ≥6.5% at study entry were associated with a multivariable-adjusted HR of 16.5 (95% CI, 14.2–19.1) for diagnosed DM based on contemporaneous diagnostic criteria and 1.95 (95% CI, 1.53–2.48) for CHD relative to those with HbA_{1c} <5.0%.[47]

Risk Factors for Developing DM

- Risk for developing type 2 DM is higher in men than in women even after accounting for other risk factors.[48–50]
- DM, especially type 2 DM, is associated with clustered risk factors for CHD, with a prevalence of 75% to 85% for hypertension among adults with DM, 70% to 80% for elevated LDL-C, and 60% to 70% for obesity.[12,51]
- Aggressive treatment of hypertension is recommended for adults with DM to prevent cardiovascular complications.[52] Between NHANES III (1984–1992) and NHANES 1999 to 2004, the proportion of patients with DM whose BP was treated increased from 76.5% to 87.8%, and the proportion whose BP was controlled nearly doubled (from 15.9% to 29.6%).[53]
- Aggressive treatment of hypercholesterolemia is recommended for adults with DM, with the cornerstone of treatment being statin therapy, which is recommended for all patients with DM >40 years of age independent of baseline cholesterol, with at least a moderate dose of statin therapy.[54]
- CHD risk factors among patients with DM remain suboptimally treated, although improvements have been observed over the past decade. Between 1999 and 2008, in up to 2623 adult participants with DM, data from NHANES showed that improvements were observed for the achieved targets for control of HbA_{1c} (from 37.0% to 55.2%), BP (from 35.2% to 51.0%), and LDL-C (from 32.5% to 52.9%).[55]
- Data from the 2012 National Healthcare Disparities Report (AHRQ, US Department of Health and Human Services) found that only ≈23% of adults >40 years of age with DM received all 4 interventions to reduce risk factors recommended for comprehensive DM care in 2009. The proportion receiving all 4 interventions was lower among blacks and Hispanics than whites.[56]
  - —In multivariable models, among those aged 40 to 64 years, only ≈65% had BP <140/8`0 mm Hg, with blacks less likely than whites to achieve this BP level.[56]
- In 1 large academic medical center, outpatients with type 2 DM were observed during an 18-month period for proportions of patients who had HbA_{1c} levels, BP, or TC levels measured; who had been prescribed any drug therapy if HbA_{1c} levels, SBP, or LDL-C levels exceeded recommended treatment goals; and who had been prescribed greater-than-starting-dose therapy if these values were above treatment goals. Patients were less likely to have cholesterol levels measured (76%) than HbA_{1c} levels (92%) or BP (99%; P<0.0001 for either comparison). The proportion of patients who received any drug therapy was greater for above-goal HbA_{1c} (92%) than for above-goal SBP (78%) or LDL-C (38%; P<0.0001 for each comparison). Similarly, patients whose HbA_{1c} levels were above the treatment goal (80%) were more likely to receive greater-than-starting-dose therapy than were those who had above-goal SBP (62%) and LDL-C levels (13%; P<0.0001).[57]
- CVD risk factors among women with DM were managed less aggressively than among men with DM. Women were less likely than men to have HbA_{1c} <7% (without CHD: adjusted OR for women versus men 0.84, P=0.005; with CHD: 0.63, P<0.0001). Women without CHD were less likely than men to be treated with lipid-lowering medication (0.82; P=0.01) or, when treated, to have LDL-C levels <100 mg/dL (0.75; P=0.004), and were less likely than men to be prescribed aspirin (0.63; P<0.0001). Women with DM and CHD were less likely than men to be prescribed aspirin (0.70, P<0.0001) and, when treated for hypertension or hyperlipidemia, were less likely to have BP levels <130/80 mm Hg (0.75; P<0.0001) or LDL-C levels <100 mg/dL (0.80; P=0.006).[58]
- Analysis of data from the CHS of the NHLBI found that lifestyle risk factors assessed late in life, including PA level, dietary habits, smoking habits, alcohol use, and adiposity measures, were each independently associated with risk of new-onset DM. Participants whose PA level and dietary, smoking, and alcohol habits were all in the low-risk group had an 82% lower incidence of DM than all other participants. When absence of adiposity was added to the other 4 low-risk lifestyle factors, incidence of DM was 89% lower.[59]
- A recent large meta-analysis suggests that exercise interventions significantly improved lipid profile, glucose tolerance, and insulin sensitivity among healthy adults.[60] In a study of 69 885 patients referred for treadmill testing in a single US healthcare system, higher fitness was associated with a lower risk of incident DM regardless of demographic

characteristics and baseline risk factors.[61] However, according to 2007 data from the BRFSS, only 25% of adults with DM achieved recommended levels of total PA based on the 2007 American Diabetes Association guidelines.[62]

- On the basis of meta-analyses of 4 longitudinal cohort studies comprising 175 938 individuals and 1.1 million person-years of follow-up, a statistically significant adjusted association was observed between net duration of television viewing and risk for incident type 2 DM, with a 20% increased risk per each 2-hour daily increment of exposure (adjusted RR, 1.20; 95% CI, 1.14–1.27).[63]

Hospitalizations

(See Table 10-1.)

Youth

- Nationwide Inpatient Sample data from 1993 to 2004 were analyzed for individuals 0 to 29 years of age with a diagnosis of DM. Rates of hospitalizations increased by 38%. Hospitalization rates were higher for females (42%) than for males (29%). Inflation-adjusted total charges for DM hospitalizations increased 130%, from $1.05 billion in 1993 to $2.42 billion in 2004.[64]

Adults

- According to NHDS data reported by the CDC in an analysis of data from 2010, DM was a listed diagnosis in 16% of US adult hospital discharges. Of the 5.1 million discharges with DM listed, circulatory diseases was the most common first-listed diagnosis (24.1%; 1.3 million discharges) and DM the second most common (11.5%; 610 000 discharges).[65]

Hypoglycemia

- Hypoglycemia is a common side effect of DM treatment, typically defined as a blood glucose level <50 mg/dL; severe hypoglycemia is additionally defined as patients who need assistance to treat themselves. In the ADVANCE trial, 2.1% of the DM patients had an episode of severe hypoglycemia.
- Severe hypoglycemia was associated with an increased risk of major macrovascular events (HR, 2.88; 95% CI, 2.01–4.12), cardiovascular death (HR, 2.68; 95% CI, 1.72–4.19), and all-cause death (HR, 2.69; 95% CI, 1.97–3.67), including nonvascular outcomes. The lack of specificity of hypoglycemia with vascular outcomes suggests that it might be a marker for susceptibility. Risk factors for hypoglycemia included older age, DM duration, worse renal function, lower BMI, lower cognitive function, use of multiple glucose-lowering medications, and randomization to the intensive glucose control arm.[66]
- According to data from the 2004 to 2008 MarketScan database of type 2 DM, which consisted of 536 581 individuals, the incidence rate of hypoglycemia was 153.8 per 10 000 person-years and was highest in adults aged 18 to 34 years (218.8 per 10 000 person-years).[67]

Cost

(See Table 10-1.)

- In 2012, the cost of DM was estimated at $245 billion, up from $174 billion in 2007, accounting for 1 in 5 healthcare dollars.[68] Of these costs, $176 billion were direct medical costs and $69 billion resulted from reduced productivity. Inpatient care accounted for 43% of these costs, 18% were attributable to prescription costs to treat DM complications, and 12% were related to antidiabetes agents and supplies.[68]
- After adjustment for age and sex, medical costs for patients with DM were 2.3 times higher than for people without DM.[14]
- According to the insurance claims and MarketScan data from 7556 youth <19 years of age with insulin-treated DM, costs for youths with hypoglycemia were $12 850 compared with $8970 for youths without hypoglycemia. For diabetic ketoacidosis, costs were $14 236 for youths with versus $8398 for youths without diabetic ketoacidosis.[69]
- The cost of hypoglycemia, according to data from 536 581 individuals with type 2 DM from the 2004 to 2008 MarketScan database, was $52 223 675, which accounted for 1.0% of inpatient costs, 2.7% of ED costs, and 0.3% of outpatient costs. This resulted in a mean cost of $17 564 for an inpatient admission, $1387 for an ED visit, and $394 for an outpatient visit.[67]

Type 1 DM

- Type 1 DM constitutes 5% to 10% of DM in the United States.[70]
- The Colorado IDDM Study Registry and SEARCH for Diabetes in Youth registry demonstrated an increasing incidence of type 1 DM among Colorado youths ≤17 years of age, with an increase in the incidence of 2.3% (95% CI, 1.6%–3.1%) per year over the past 26 years.[71]
- Between 1996 and 2010, the number of youths with type 1 DM increased by 5.7% per year.[72]
- Among youths with type 1 DM, the prevalence of overweight is 22.1% and the prevalence of obesity is 12.6%.[6]
- A long-term study of patients with type 1 DM that began in 1966 showed that over 30 years of follow-up, overall risk of mortality associated with type 1 DM was 7 times greater than that of the general population. Females had a 13.2-fold incremental mortality risk compared with a 5.0-fold increased risk in males. During the course of study, the incremental mortality risk associated with type 1 DM declined from 9.3 to 5.6 times that of nondiabetic control subjects.[73]
- According to 30-year mortality data from Allegheny County, PA, those with type 1 DM have a mortality rate 5.6 times higher than the general population.[74]
- The leading cause of death among patients with type 1 DM is CVD, which accounted for 22% of deaths among those in the Allegheny County, PA, type 1 DM registry, followed by renal (20%) and infectious (18%) causes.[75]
- Long-term follow-up data from the DCCT/EDIC Study Research Group showed that intensive versus conventional treatment in the DCCT was associated with a 42% reduced risk of CVD (P=0.02) and a 57% reduced risk of the composite end point (P=0.02; included nonfatal MI, stroke, and CVD death).[76]
- Among 3610 older patients (>60 years of age) with type 1 DM, the risk of severe hypoglycemia was twice as high

as for those <60 years of age (40.1 versus 24.3 per 100 patient-years).[77]

Global Burden of DM

- The prevalence of DM for adults worldwide was estimated to be 6.4% in 2010 and is projected to be 7.7% in 2030. The total number of people with DM is projected to rise from 285 million in 2010 to 439 million in 2030.[78]
- According to international survey and epidemiological data from 2.7 million participants, the prevalence of DM in adults increased from 8.3% in men and 7.5% in women in 1980 to 9.8% in men and 9.2% in women in 2008. The number of individuals affected with DM increased from 153 million in 1980 to 347 million in 2008.[79]
- In 2010, DM and other endocrine disorders caused >2.7 million deaths worldwide, accounting for 5.2% of all deaths.[80]

Table 10-1. Diabetes Mellitus

Population Group	Prevalence of Physician-Diagnosed DM, 2012: Age ≥20 y	Prevalence of Undiagnosed DM, 2012: Age ≥20 y	Prevalence of Prediabetes, 2012: Age ≥20 y	Incidence of Diagnosed DM: Age ≥20 y*	Mortality, 2013: All Ages†	Hospital Discharges, 2010: All Ages	Cost, 2012‡
Both sexes	21 100 000 (8.5%)	8 100 000 (3.3%)	80 800 000 (35.3%)	1 700 000	75 578	630 000	$245 Billion
Males	10 500 000 (9.0%)	5 100 000 (4.4%)	46 400 000 (42.4%)	…	39 841 (52.7%)§	311 000	…
Females	10 600 000 (8.0%)	3 000 000 (2.4%)	34 400 000 (28.4%)	…	35 737 (47.3%)§	319 000	…
NH white males	7.6%	4.0%	43.0%	…	27 807	…	…
NH white females	6.1%	1.7%	28.9%	…	23 490	…	…
NH black males	13.8%	4.8%	36.3%	…	6298	…	…
NH black females	14.6%	2.3%	27.8%	…	6941	…	…
Hispanic males	12.5%	6.8%	43.0%	…	3934	…	…
Hispanic females	11.8%	5.0%	26.0%	…	3698	…	…
NH Asian or Pacific Islander	…	…	…	…	2271	…	…
NH American Indian or Alaska Native	…	…	…	…	922	…	…

Undiagnosed DM is defined as those whose fasting glucose is ≥126 mg/dL but who did not report being told by a healthcare provider that they had DM. Prediabetes is a fasting blood glucose of 100 to <126 mg/dL (impaired fasting glucose); prediabetes includes impaired glucose tolerance. DM indicates diabetes mellitus; ellipses (…), data not available; and NH, non-Hispanic.

*Centers for Disease Control and Prevention, National Diabetes Statistics Report, 2014.[11]

†Mortality for Hispanic, American Indian or Alaska Native, and Asian and Pacific Islander people should be interpreted with caution because of inconsistencies in reporting Hispanic origin or race on the death certificate compared with censuses, surveys, and birth certificates. Studies have shown underreporting on death certificates of American Indian or Alaska Native, Asian and Pacific Islander, and Hispanic decedents, as well as undercounts of these groups in censuses.

‡Yang et al.[68]

§These percentages represent the portion of total DM mortality that is for males vs females.

Sources: Prevalence: Prevalence of diagnosed and undiagnosed DM: National Health and Nutrition Examination Survey 2009 to 2012, National Center for Health Statistics (NCHS), and National Heart, Lung, and Blood Institute. Percentages for racial/ethnic groups are age adjusted for Americans ≥20 years of age. Age-specific percentages are extrapolations to the 2012 US population estimates. Mortality: Centers for Disease Control and Prevention/NCHS, 2013 Mortality Multiple Cause-of-Death–United States. These data represent underlying cause of death only. Hospital discharges: National Hospital Discharge Survey, NCHS; data include those inpatients discharged alive, dead, or status unknown.

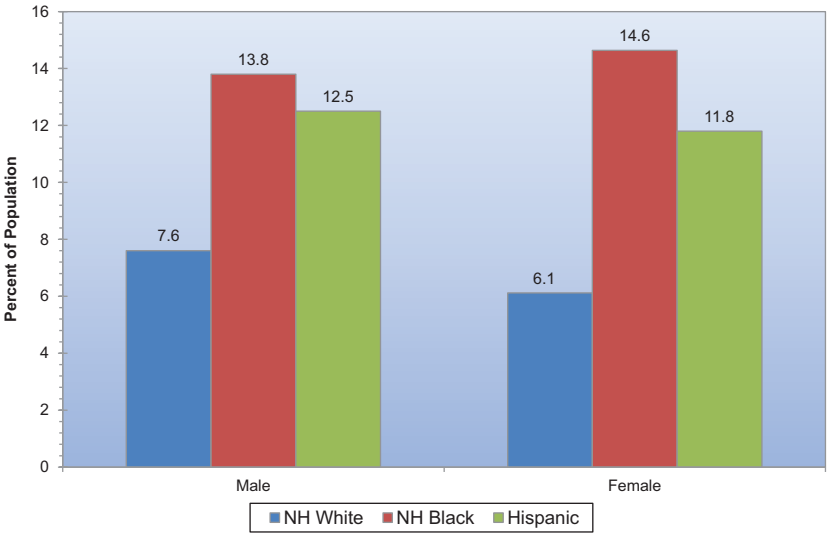

Chart 10-1. Age-adjusted prevalence of physician-diagnosed diabetes mellitus in adults ≥20 years of age by race/ethnicity and sex (National Health and Nutrition Examination Survey: 2009–2012). NH indicates non-Hispanic. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

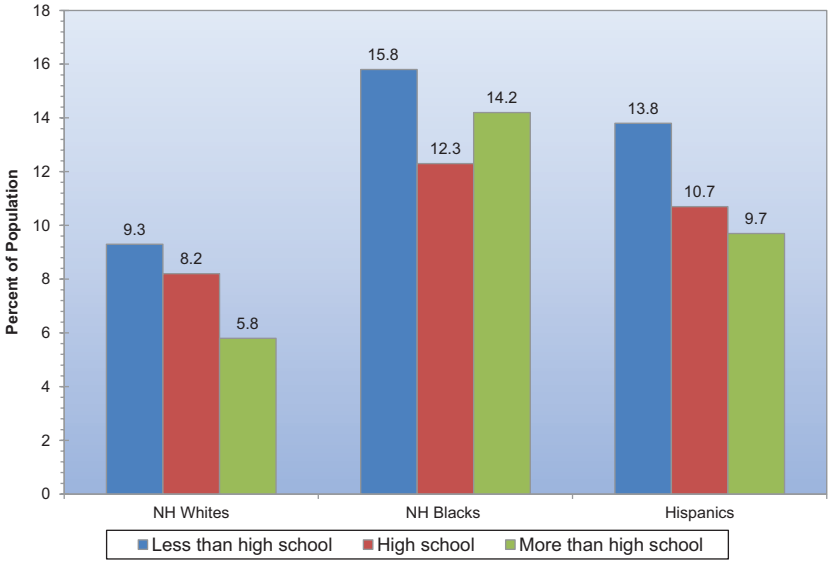

Chart 10-2. Age-adjusted prevalence of physician-diagnosed diabetes mellitus in adults ≥20 years of age by race/ethnicity and years of education (National Health and Nutrition Examination Survey: 2009–2012). NH indicates non-Hispanic. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

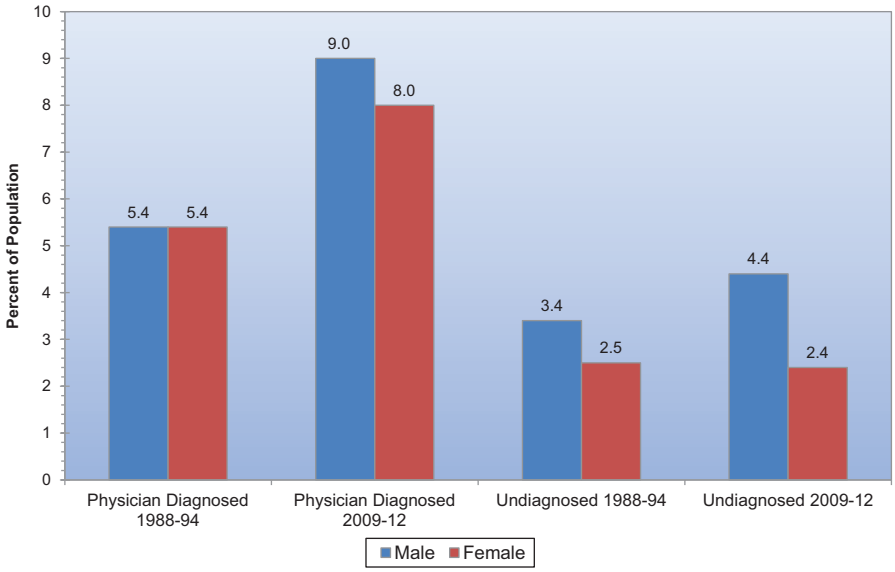

Chart 10-3. Trends in diabetes mellitus prevalence in adults ≥20 years of age by sex (National Health and Nutrition Examination Survey: 1988–1994 and 2009–2012). Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

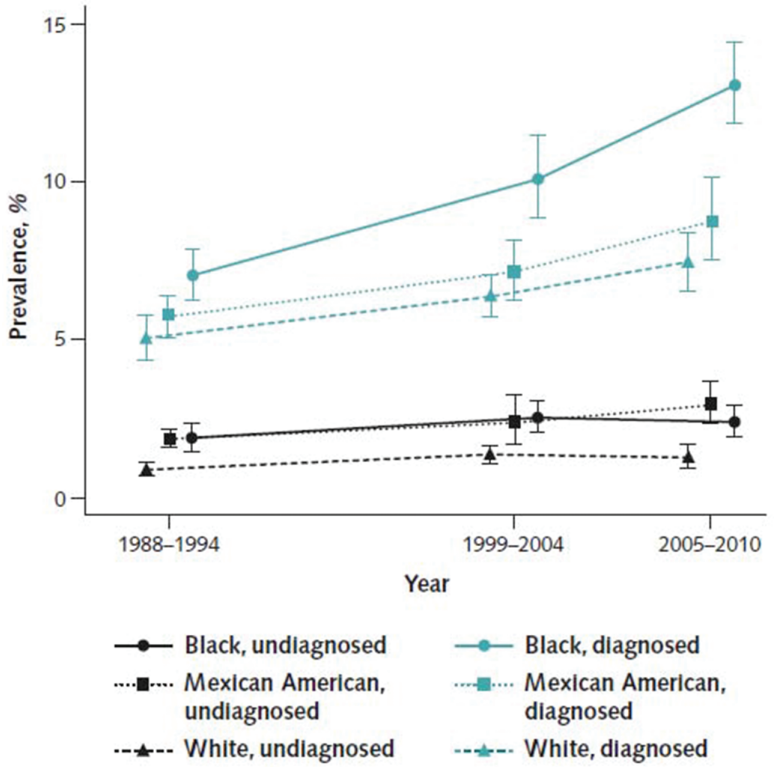

Chart 10-4. Trends in the prevalence of diagnosed and undiagnosed diabetes mellitus (calibrated hemoglobin A_{1c} levels >6.5%), by race/ethnic group. Data from US adults aged 20 years in National Health and Nutrition Examination Survey (NHANES) 1988 to 1994, 1999 to 2004, and 2005 to 2010. Source: NHANES.[12]

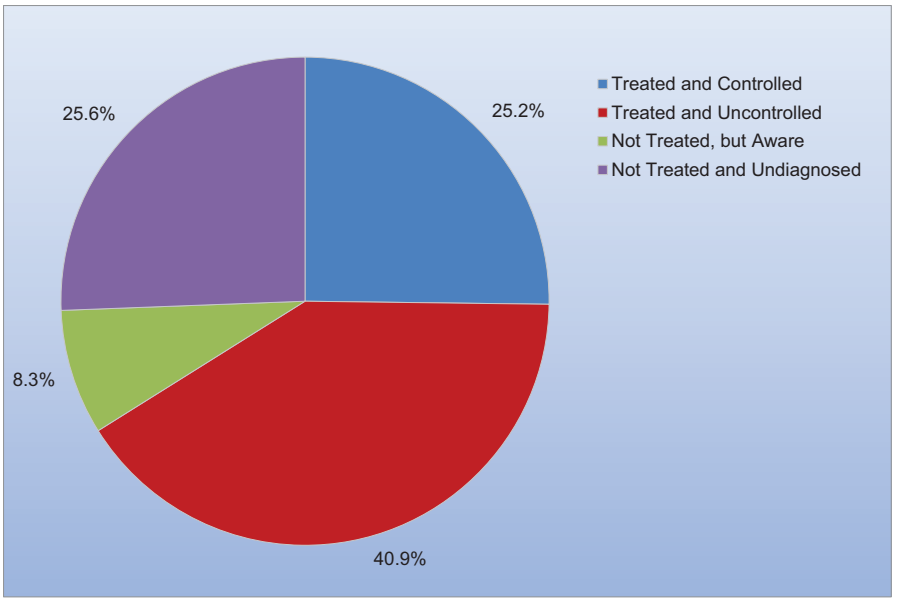

Chart 10-5. Diabetes mellitus awareness, treatment, and control in adults ≥20 years of age (National Health and Nutrition Examination Survey: 2009–2012). Source: National Heart, Lung, and Blood Institute.

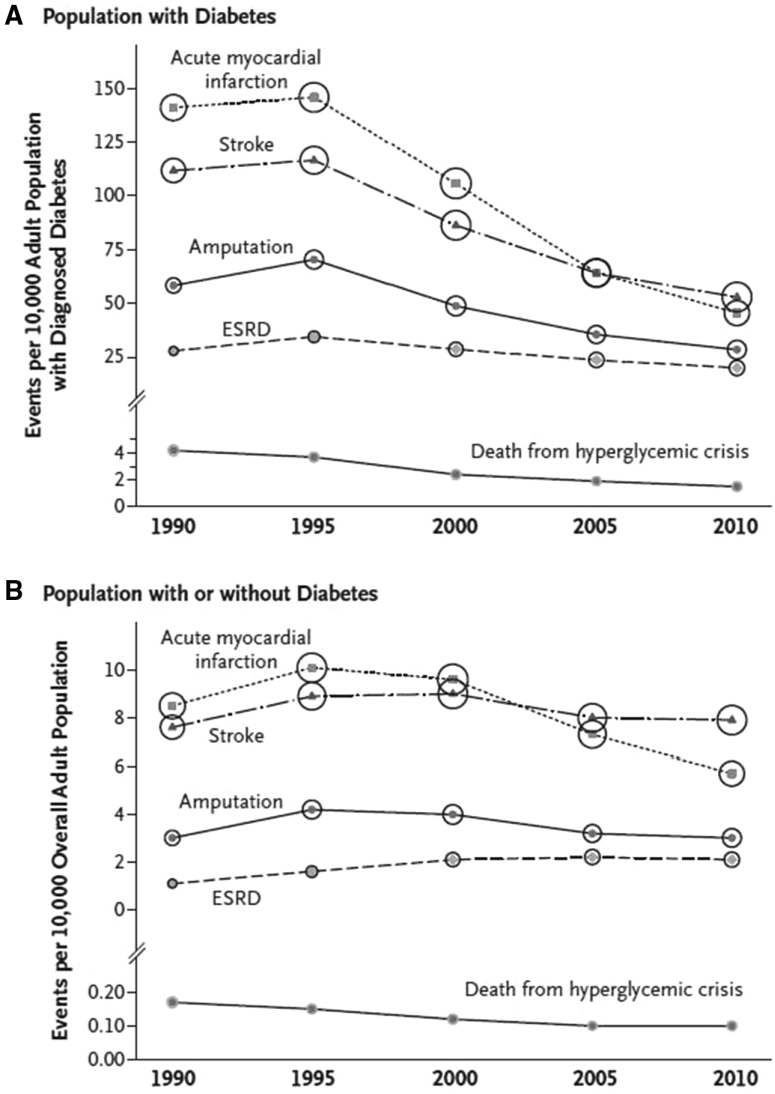

Chart 10-6. Trends in age-standardized rates of diabetes mellitus–related complications among US adults with and without diagnosed diabetes. ESRD indicates end-stage renal disease. Reprinted from Gregg et al[37] with permission from the publisher. Copyright © 2014, Massachusetts Medical Society.

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11. Metabolic Syndrome

See Charts 11-1 through 11-8.

- Metabolic syndrome is a multicomponent risk factor for CVD and type 2 DM that reflects the clustering of individual cardiometabolic risk factors related to abdominal obesity and insulin resistance. Clinically, metabolic syndrome is a useful entity for communicating the nature of lifestyle-related cardiometabolic risk to both patients and other clinicians. Although several different clinical definitions for metabolic syndrome have been proposed, the International Diabetes Federation, NHLBI, AHA, and others recently proposed a harmonized definition for metabolic syndrome.[1]

By this definition, metabolic syndrome is diagnosed when any 3 of the following 5 risk factors are present:

—Fasting plasma glucose ≥100 mg/dL or undergoing drug treatment for elevated glucose
—HDL-C <40 mg/dL in men or <50 mg/dL in women or undergoing drug treatment for reduced HDL-C
—Triglycerides ≥150 mg/dL or undergoing drug treatment for elevated triglycerides
—Waist circumference >102 cm in men or >88 cm in women for people of most ancestries living in the United States. Ethnicity and country-specific thresholds can be used for diagnosis in other groups, particularly Asians and individuals of non-European ancestry who have predominantly resided outside the United States.

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Abbreviations Used in Chapter 11

ACC	American College of Cardiology
AF	atrial fibrillation
AHA	American Heart Association
ARIC	Atherosclerosis Risk in Communities
ASCVD	atherosclerotic cardiovascular disease
ATP III	Adult Treatment Panel III
BIOSHARE-EU	Biobank Standardization and Harmonization for Research Excellence in the European Union
BMI	body mass index
BP	blood pressure
CAC	coronary artery calcification
CAD	coronary artery disease
CARRS	Center for Cardiometabolic Risk Reduction in South Asia
CDC	Centers for Disease Control and Prevention
CHD	coronary heart disease
CHRIS	Collaborative Health Research in South Tyrol Study
CI	confidence interval
COURAGE	Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation
CRP	C-reactive protein
CT	computed tomography
CVD	cardiovascular disease
DESIR	Data From an Epidemiological Study on the Insulin Resistance Syndrome
DILGOM	Dietary, Lifestyle, and Genetics Determinants of Obesity and Metabolic Syndrome
DM	diabetes mellitus
ECG	electrocardiogram
EGCUT	Estonian Genome Center of the University of Tartu
FRS	Framingham Risk Score
HCHS/SOL	Hispanic Community Health Study/Study of Latinos
HDL	high-density lipoprotein
HDL-C	high-density lipoprotein cholesterol
HF	heart failure
HIV	human immunodeficiency virus
HR	hazard ratio
HUNT2	Nord-Trøndelag Health Study
IMT	intima-media thickness
KNHANES	Korean National Health and Nutrition Examination Survey
KORA	Cooperative Health Research in the Region of Augsburg
LDL-C	low-density lipoprotein cholesterol
LV	left ventricular
MASALA	Mediators of Atherosclerosis in South Asians Living in America
MESA	Multi-Ethnic Study of Atherosclerosis
MetS	metabolic syndrome
Mex.-Am.	Mexican American
MHO	metabolically healthy obesity
MI	myocardial infarction
MICROS	Microisolates in South Tyrol Study
MORGAM	MONICA [Monitoring Trends and Determinants in Cardiovascular Disease], Risk, Genetics, Archiving and Monograph Project
NCDS	National Child Development Study
NCHS	National Center for Health Statistics
NHANES	National Health and Nutrition Examination Survey
NHLBI	National Heart, Lung, and Blood Institute
NIPPON DATA	National Integrated Project for Prospective Observation of Noncommunicable Disease and Its Trends in Aged
NL	The Netherlands
OR	odds ratio
PA	physical activity
PAR	population attributable risk
PREVEND	Prevention of Renal and Vascular End-Stage Disease
RCT	randomized controlled trial
RR	relative risk
TG	triglycerides
VTE	venous thromboembolism
Waist circumf.	waist circumference
WC	waist circumference
WHO	World Health Organization

—BP ≥130 mm Hg systolic or ≥85 mm Hg diastolic or undergoing drug treatment for hypertension, or antihypertensive drug treatment in a patient with a history of hypertension.

- The new harmonized metabolic syndrome definition identifies a similar risk group and predicts CVD risk similarly to the prior metabolic syndrome definitions.[2]
- There are many adverse health conditions that are related to metabolic syndrome but are not part of its clinical definition. These include nonalcoholic fatty liver disease, sexual/reproductive dysfunction (erectile dysfunction in men and polycystic ovarian syndrome in women), obstructive sleep apnea, certain forms of cancer, and possibly osteoarthritis, as well as a general proinflammatory and prothrombotic state.[3]
- Those with a fasting glucose level ≥126 mg/dL or a casual glucose value ≥200 mg/dL or taking hypoglycemic medication will normally be classified separately as having DM; many of these people will also have metabolic syndrome because of the presence of ≥2 of the additional risk factors noted above. For treatment purposes, many will prefer to separate those with DM into a separate group.
- Identification and treatment of metabolic syndrome fits closely with the current AHA 2020 Impact Goals, including emphasis on PA, healthy diet, and healthy weight for attainment of ideal BP, serum cholesterol, and fasting blood glucose. Metabolic syndrome should be considered largely a disease of unhealthy lifestyle. Prevalence of metabolic syndrome is a secondary metric in the 2020 Impact Goals. Identification of metabolic syndrome represents a call to action for the healthcare provider and patient to address the underlying lifestyle-related risk factors. A multidisciplinary team of healthcare professionals is desirable to adequately address these multiple issues in patients with metabolic syndrome.[4]
- Despite its prevalence (see below), the public's recognition of metabolic syndrome is limited.[5] A diagnosis of metabolic syndrome may increase risk perception and motivation toward a healthier behavior.[6]

Prevalence

Youth

(See Chart 11-1.)

- According to the 2009 AHA scientific statement about metabolic syndrome in children and adolescents, metabolic syndrome should be diagnosed with caution in this age group, because metabolic syndrome categorization in adolescents is not stable.[7] Approximately half of the 1098 adolescent participants in the Princeton School District Study diagnosed with pediatric ATP III metabolic syndrome lost the diagnosis over 3 years of follow-up.[8] Despite this, mathematical research in the form of confirmatory factor analysis strongly suggests the existence of a single grouping of cardiometabolic risk factors shared in common across the spectrum from children to adults.[9]
- Additional evidence of the instability of the diagnosis of metabolic syndrome in children exists. In children 6 to 17 years of age participating in research studies in a single clinical research hospital, the diagnosis of metabolic syndrome was unstable in 46% of cases after a mean of 5.6 years of follow-up.[10]
- Uncertainty remains concerning the definition of the obesity component of metabolic syndrome in the pediatric population because it is age dependent. Therefore, use of BMI percentiles[11] and waist-height ratio[12] has been recommended. Using standard CDC and FitnessGram standards for pediatric obesity, the prevalence of metabolic syndrome in obese youth ranges from 19% to 35%.[11] On the basis of NHANES 1999 to 2002 data, the prevalence of metabolic syndrome in adolescents 12 to 19 years of age was 9.4%, which represents ≈2.9 million people. It was 13.2% in boys, 5.3% in girls, 10.7% in whites, 5.2% in blacks, and 11.1% in Mexican Americans.[13]
- In 1999 to 2004, ≈4.5% of US adolescents 12 to 17 years of age had metabolic syndrome according to the definition developed by the International Diabetes Federation.[14] In 2006, this prevalence would have represented ≈1.1 million adolescents 12 to 17 years of age with metabolic syndrome. It increased from 1.2% among those 12 to 13 years of age to 7.1% among those 14 to 15 years of age and was higher among boys (6.7%) than girls (2.1%). Furthermore, 4.5% of white adolescents, 3.0% of black adolescents, and 7.1% of Mexican American adolescents had metabolic syndrome.
- In the most recent report using NHANES data, the age-adjusted prevalence of metabolic syndrome in those aged 12 to 19 years appeared to be decreasing. In this report, the age-adjusted prevalence from 1988 to 1994 was 7.3%, dropping to 6.7% from 1999 to 2002 and to 6.5% from 2003 to 2006. This is in contrast to the Korean NHANES, in which the prevalence of metabolic syndrome in those aged 12 to 19 years increased from 4.0% to 7.8%. In the United States, improvements in HDL-C and BP led to the decreased prevalence, whereas increases in dyslipidemia and abdominal obesity contributed to the increasing prevalence in Korea.[15]
- Of 31 participants in the NHLBI Lipid Research Clinics Princeton Prevalence Study and the Princeton Follow-Up Study who had metabolic syndrome at baseline, 21 (68%) had metabolic syndrome 25 years later.[16] After adjustment for age, sex, and race, the baseline status of metabolic syndrome was significantly associated with an increased risk of having metabolic syndrome during adulthood (OR, 6.2; 95% CI, 2.8–13.8).
- In the Bogalusa Heart Study, 4 variables (BMI, homeostasis model assessment of insulin resistance, ratio of triglycerides to HDL-C, and mean arterial pressure) considered to be part of metabolic syndrome clustered together in blacks and whites and in both children and adults[17]; however the degree of clustering was stronger among adults than among children. As in adults, preclinical cardiovascular abnormalities, such as elevated carotid IMT, are closely associated with metabolic syndrome in children and adolescents.[18,19]

Adults

(See Charts 11-2 through 11-7.)

The following estimates include many who also have DM, in addition to those with metabolic syndrome without DM:

- Prevalence of metabolic syndrome varies by the definition used, with definitions such as that from the International

Diabetes Federation and the harmonized definition suggesting lower thresholds for defining central obesity in European whites, Asians (in particular, South Asians), Middle Easterners, Sub-Saharan Africans, and Hispanics, which results in higher prevalence estimates.[20]

- The phenotypic expression of metabolic syndrome also varies by race/ethnicity[21] and is likely influenced by genetic factors. For example, in population-based US data, nonalcoholic fatty liver disease is present in only 18% of African Americans with metabolic syndrome but is present in 39% of Hispanics with metabolic syndrome.[22] The phenotypic expression of metabolic syndrome also varies by country and culture, particularly in Europe.[23]
- On the basis of data from NHANES 1999 to 2010, the age-adjusted prevalence of metabolic syndrome in the United States has peaked (in the 2001–2002 cycle) and has begun to fall.[24]
  - —In the 1999 to 2000 cycle, the age-adjusted prevalence of metabolic syndrome was 25.54%. In 2001 to 2002, the age-adjusted prevalence peaked at 27.37%. In 2009 to 2010, the age-adjusted prevalence was 22.90%.
  - —Although the age-adjusted prevalence of metabolic syndrome has remained flat over time in men, the age-adjusted prevalence in women has decreased. In 1999 to 2000, the age-adjusted prevalence was 23.35% in men and 27.50% in women. In 2009 to 2010, the age adjusted prevalence was 23.69% in men and 21.80% in women. A more recent NHANES report using 2012 data also suggests declining overall rates in women.[25]
  - —The reduced prevalence of metabolic syndrome has been observed predominantly in non–Mexican American whites, in whom the age-adjusted prevalence has fallen from 25.59% in 1999 to 2000 to 21.77% in 2009 to 2010. In contrast, the prevalence of metabolic syndrome in non–Mexican American blacks and Mexican Americans has remained stable.
  - —Although the age-adjusted prevalence of metabolic syndrome was once higher in non-Mexican American whites than in non–Mexican American blacks, the age-adjusted prevalence in 2009 to 2010 was similar between these groups. In 2009 to 2010, the age-adjusted prevalence of metabolic syndrome was 40% to 46% higher among Mexican Americans than among non–Mexican American whites and blacks. Differences in prevalence are more pronounced in men than in women.
  - —In 2009 to 2010, the age-adjusted prevalence of metabolic syndrome was lowest among non-Mexican American black men (18.99%) and highest among Mexican American men (34.76%).
  - —The changing trends in age-adjusted metabolic syndrome prevalence are attributable to changes in the prevalence of its individual components. In general, hypertriglyceridemia and elevated BP have decreased, whereas hyperglycemia and elevated waist circumference have increased. However, these trends varied significantly by sex and race/ethnicity.
- Using different modeling strategies, other reports using NHANES 2003 to 2006 data and National Cholesterol Education Program/ATP III definitions reported an age-adjusted prevalence of ≈34% for adults ≥20 years of age.[26] Differences in the prevalence statistics are the result of different handling of age adjustment as the prevalence of metabolic syndrome increases with age and handling of medication therapy for its component conditions.
- Additionally, on the basis of NHANES 2003 to 2006 data[26]
  - —Among men, the age-specific prevalence of metabolic syndrome ranged from 20.3% among people 20 to 39 years of age to 40.8% for people 40 to 59 years of age and 51.5% for people ≥60 years of age. Among women, the age-specific prevalence ranged from 15.6% among people 20 to 39 years of age to 37.2% for people 40 to 59 years of age and 54.4% for those ≥60 years of age.
- The prevalence of metabolic syndrome is high among Hispanics/Latinos of diverse backgrounds living in the United States. Using data from the population-representative HCHS-SOL study, the overall prevalence of metabolic syndrome among Hispanics/Latinos was 34% among men and 36% among women; it increased with age, increasing from 25% to 43% to 55% among men and from 23% to 50% to 62% among women in age groups 18 to 44, 45 to 64, and 65 to 74 years, respectively. In men and women, the lowest prevalence of metabolic syndrome was observed among South Americans (27%). In men, the highest prevalence was observed in Cubans (35%), and in women, the highest prevalence was observed among Puerto Ricans (41%). Some differences in individual components exist by specific Hispanic/Latino background. See Charts 11-6 and 11-7 for complete details.[27]
- The prevalence of prediabetes is high among Indians living in the United States and might be higher than the prevalence of prediabetes among Indians living in India. In a comparison of the MASALA and CARRS studies, the prevalence of prediabetes was 33% in the United States sample and 24% in the Chennai, India, sample.[28] A low amount of exercise was most strongly associated with prediabetes in MASALA.[29] The overall prevalence of metabolic syndrome in MASALA was 34.5%.
- Other studies have confirmed that the prevalence of metabolic syndrome is high among immigrant Asian Indians, ranging between 26.8% and 38.2% depending on the definition used.[30]
- Among American Indian and Alaska Native people living in the southwestern United States, the prevalence of metabolic syndrome was reported to be 43.2% in men and 47.3% in women; among Alaska Native people, prevalences were 26.5% and 31.2%, respectively.[31]
- The prevalence of metabolic syndrome among pregnant women increased to 26.5% during 1999 to 2004 from 17.8% during 1988 to 1994.[32]
- The prevalence of metabolic syndrome has been noted to be high among select special populations, including those with schizophrenia spectrum disorders,[33] those taking atypical antipsychotic drugs,[34] those receiving prior organ transplants,[35] HIV-infected individuals,[36] those previously treated for blood cancers,[37] those with systemic inflammatory disorders such as psoriasis,[38] individuals with well-treated type I DM,[39] those with hypopituitarism,[40] those with prior gestational DM,[41] and individuals in select professions, including law enforcement[42] and firefighters.[43]

- There is a bidirectional relationship between metabolic syndrome and depression. In prospective studies, the presence of depression increases the risk of metabolic syndrome (OR, 1.49; 95% CI, 1.19–1.87), whereas metabolic syndrome increases the risk of depression (OR, 1.52; 95% CI, 1.20–1.91).[44]
- Perhaps most importantly with respect to meeting the 2020 goals, the prevalence of metabolic syndrome increases with greater cumulative life-course exposure to sedentary behavior and physical inactivity[45]; screen time, including television viewing[46]; fast food intake[47]; short sleep duration[48]; and intake of sugar-sweetened beverages.[49,50] Each of these risk factors is reversible with lifestyle change.

Global Burden of Metabolic Syndrome

(See Chart 11-8.)

- Metabolic syndrome is becoming hyperendemic around the world. Recent evidence has described the prevalence of metabolic syndrome in Canada,[51] Latin America,[52] India,[53,54] Bangladesh,[55] and Vietnam,[56] as well as many other countries. On the basis of data from NIPPON DATA, the age-adjusted prevalence of metabolic syndrome in a Japanese population was 19.3%.[57] In a partially representative Chinese population, the age-adjusted prevalence of metabolic syndrome in China was 21.3%,[58] whereas in northwest China, the prevalence was 15.1%.[59]
- In the INTERHEART case-control study of MI in 26 903 subjects from 52 countries, metabolic syndrome was present in 29.1% of case subjects and just 16.8% of control subjects. The age- and obesity-adjusted prevalence of metabolic syndrome was highest among women (32.1%), South Asians (29.8%), and other Asians (28.7%).[60]
- In a report from BIOSHARE-EU, which harmonizes modern data from 10 different population-based cohorts in 7 European countries, the age-adjusted prevalence of metabolic syndrome in obese subjects ranged from 24% to 65% in women and from 24% to 65% in men. In the obese population, the prevalence of metabolic syndrome far exceeded the prevalence of metabolically healthy obesity, which had a prevalence of 7% to 28% in women and 2% to 19% in men. The prevalence of metabolic syndrome varied considerably by European country in the BIOSHARE-EU consortium.[61]
- The prevalence of metabolic syndrome has been reported to be low (14.6%) in a population-representative study in France compared with other industrialized countries.[62]
- In a recent systematic review of 10 Brazilian studies, the weighted mean prevalence of metabolic syndrome in Brazil was 29.6%.[63]
- In a report from a representative survey of the northern State of Nuevo León, Mexico, the prevalence of metabolic syndrome in adults ≥16 years old was 54.8%. In obese adults, the prevalence reached 73.8%. The prevalence in adult North Mexican women (60.4%) was higher than in adult North Mexican men (48.9%).[64]
- Metabolic syndrome is highly prevalent in modern indigenous populations, notably in Brazil[63] and Australia. The prevalence of metabolic syndrome was estimated to be 33.0% in Australian Aborigines and 50.3% in Torres Strait Islanders.[65]

Risk

Youth

- Few prospective pediatric studies have examined the future risk for CVD or DM according to baseline metabolic syndrome status. Data from 771 participants 6 to 19 years of age from the NHLBI's Lipid Research Clinics Princeton Prevalence Study and the Princeton Follow-up Study showed that the risk of developing CVD was substantially higher among those with metabolic syndrome than among those without this syndrome (OR, 14.6; 95% CI, 4.8–45.3) who were followed up for 25 years.[16]
- Another analysis of 814 participants in this cohort showed that those 5 to 19 years of age who had metabolic syndrome at baseline had an increased risk of having DM 25 to 30 years later compared with those who did not have the syndrome at baseline (OR, 11.5; 95% CI, 2.1–63.7).[66]
- Additional data from the Princeton Follow-Up Study, the Fels Longitudinal Study, and the Muscatine Study suggest that the absence of components of metabolic syndrome in childhood has a high negative predictive value for the development of metabolic syndrome or DM in adulthood.[67]
- In a study of 6328 subjects from 4 prospective studies, compared with people with normal BMI as children and as adults, those with consistently high adiposity from childhood to adulthood had an increased risk of the following metabolic syndrome components: hypertension (RR, 2.7; 95% CI, 2.2–3.3), low HDL-C (RR, 2.1; 95% CI, 1.8–2.5), elevated triglycerides (RR, 3.0; 95% CI, 2.4–3.8), type 2 DM (RR, 5.4; 95% CI, 3.4–8.5), and increased carotid IMT (RR, 1.7; 95% CI, 1.4–2.2). Those who were overweight or obese during childhood but were not obese as adults had no increased risk compared with those with consistently normal BMI.[68]
- In 1757 youths from the Bogalusa Heart Study and the Cardiovascular Risk in Young Finns Study, those with metabolic syndrome in youth and adulthood were at 3.4 times increased risk of high carotid IMT and 12.2 times increased risk of type 2 DM in adulthood as those without metabolic syndrome at either time. Adults whose metabolic syndrome had resolved after their youth were at no increased risk of having high IMT or type 2 DM.[69]

Adults

- Consistent with 2 earlier meta-analyses, a recent meta-analysis of prospective studies concluded that metabolic syndrome increased the risk of developing CVD (summary RR, 1.78; 95% CI, 1.58–2.00).[70] The risk of CVD tended to be higher in women (summary RR, 2.63) than in men (summary RR, 1.98; P=0.09). On the basis of results from 3 studies, metabolic syndrome remained a predictor of cardiovascular events after adjustment for the individual components of the syndrome (summary RR, 1.54; 95% CI, 1.32–1.79). A more recent meta-analysis among 87 studies comprising 951 083 subjects showed an even higher risk of CVD associated with metabolic syndrome (summary RR, 2.35; 95% CI, 2.02–2.73), with significant increased risks (RRs ranging from 1.6 to 2.9) for all-cause mortality, CVD mortality, MI, and stroke, as well as for those with metabolic syndrome without DM.[71]

- In one of the earlier studies among US adults, mortality follow-up of the second NHANES showed a stepwise increase in risk of CHD, CVD, and total mortality across the spectrum of no disease, metabolic syndrome (without DM), DM, prior CVD, and those with CVD and DM, with an HR for CHD mortality of 2.02 (95% CI, 1.42–2.89) associated with metabolic syndrome. Increased risk was seen with increased numbers of metabolic syndrome risk factors.[72]
- Estimates of RR for CVD generally increase as the number of components of metabolic syndrome increases.[73] Compared with men without an abnormal component in the Framingham Offspring Study, the HRs for CVD were 1.48 (95% CI, 0.69–3.16) for men with 1 or 2 components and 3.99 (95% CI, 1.89–8.41) for men with ≥3 components.[74] Among women, the HRs were 3.39 (95% CI, 1.31–8.81) for 1 or 2 components and 5.95 (95% CI, 2.20–16.11) for ≥3 components. Compared with men without a metabolic abnormality in the British Regional Heart Study, the HRs were 1.74 (95% CI, 1.22–2.39) for 1 component, 2.34 (95% CI, 1.65–3.32) for 2 components, 2.88 (95% CI, 2.02–4.11) for 3 components, and 3.44 (95% CI, 2.35–5.03) for 4 or 5 components.[73]
- The cardiovascular risk associated with metabolic syndrome varies on the basis of the combination of metabolic syndrome components present. Of all possible ways to have 3 metabolic syndrome components, the combination of central obesity, elevated BP, and hyperglycemia conferred the greatest risk for CVD (HR, 2.36; 95% CI, 1.54–3.61) and mortality (HR, 3.09; 95% CI, 1.93–4.94) in the Framingham Offspring Study.[75]
- Data from the Aerobics Center Longitudinal Study indicate that risk for CVD mortality is increased in men without DM who have metabolic syndrome (HR, 1.8; 95% CI, 1.5–2.0); however, among those with metabolic syndrome, the presence of DM is associated with even greater risk for CVD mortality (HR, 2.1; 95% CI, 1.7–2.6).[76] Analysis of data from NCHS was used to determine the number of disease-specific deaths attributable to all nonoptimal levels of each risk factor exposure by age and sex. The results of the analysis of dietary, lifestyle, and metabolic risk factors show that targeting a handful of risk factors has large potential to reduce mortality in the United States.[77]
- Among stable CAD patients in the COURAGE trial, the presence of metabolic syndrome was associated with an increased risk of death or MI (unadjusted HR, 1.41; 95% CI, 1.15–1.73; P=0.001); however, after adjustment for its individual components, metabolic syndrome was no longer significantly associated with outcome (HR, 1.15; 95% CI, 0.79–1.68; P=0.46).[78]
- In the INTERHEART case-control study of 26 903 subjects from 52 countries, metabolic syndrome was associated with an increased risk of MI, both according to the WHO (OR, 2.69; 95% CI, 2.45–2.95) and the International Diabetes Federation (OR, 2.20; 95% CI, 2.03–2.38) definitions, with a PAR of 14.5% (95% CI, 12.7%–16.3%) and 16.8% (95% CI, 14.8%–18.8%), respectively, and associations that were similar across all regions and ethnic groups. In addition, the presence of ≥3 risk factors with subthreshold values was associated with increased risk of MI (OR, 1.50; 95% CI, 1.24–1.81) compared with having "normal" values. Similar results were observed when the International Diabetes Federation definition was used.[60]
- In the Three-City Study, among 7612 participants aged ≥65 years who were followed up for 5.2 years, metabolic syndrome was associated with increased total CHD (HR, 1.78; 95% CI, 1.39–2.28) and fatal CHD (HR, 2.40; 95% CI, 1.41–4.09); however, metabolic syndrome was not associated with CHD beyond its individual risk components.[79]
- The United States has a higher prevalence of metabolic syndrome and a higher CVD mortality rate than Japan. It is estimated that 13.3% to 44% of the excess CVD mortality in the Unites States is explained by metabolic syndrome or metabolic syndrome–related existing CVD.[57]
- In MESA, among 6603 people aged 45 to 84 years (1686 [25%] with metabolic syndrome without DM and 881 [13%] with DM), subclinical atherosclerosis assessed by CAC was more severe in people with metabolic syndrome and DM than in those without these conditions, and the extent of CAC was a strong predictor of CHD and CVD events in these groups.[80] Furthermore, the progression of CAC was greater in people with metabolic syndrome and DM than in those without, and progression of CAC predicted future CVD event risk both in those with metabolic syndrome and in those with DM.[81,82]
- In addition to CVD, metabolic syndrome has been associated with incident AF,[83] recurrent AF after ablation,[84] HF,[85] and cognitive decline.[86] Data from case-control studies, but not prospective studies, support an association with VTE.[87] There may be an association with increased incident asthma.[88]
- Although associated with increased risk,[89] metabolic syndrome is not designed to be risk predictive tool and should not be compared to dedicated risk prediction tools such as the FRS[90] or the new 2013 ACC/AHA ASCVD risk estimator.[91] For example, using the 36 cohorts represented in the MORGAM Project, the prognosis associated with metabolic syndrome has been shown to vary substantially by age and sex.[92]
- Metabolic syndrome is associated with increased healthcare use and healthcare-related costs among individuals with and without DM. Overall, healthcare costs increase by ≈24% for each additional metabolic syndrome component present.[93]

Risk Factors

- Risk of metabolic syndrome probably begins before birth. The Prediction of Metabolic Syndrome in Adolescence Study showed that the coexistence of low birth weight, small head circumference, and parental history of overweight or obesity places children at the highest risk for metabolic syndrome in adolescence. Other risk factors identified included parental history of DM, gestational hypertension in the mother, and lack of breastfeeding.[94] However, a recent RCT testing a breastfeeding promotion intervention did not lead to reduced childhood metabolic syndrome among healthy term infants.[95]
- In prospective or retrospective cohort studies, the following factors have been reported as being directly associated with incident metabolic syndrome, defined by 1 of the major definitions: age,[24] low educational attainment,[96,97] low socioeconomic status,[98] not being able to understand or read food labels,[99] urbanization,[100] smoking,[97,98,101,102] parental

smoking,[103] low levels of PA,[97,98,101,102] low levels of physical fitness,[104–106] intake of soft drinks,[107] intake of diet soda,[108] fructose intake,[109] magnesium intake,[110,111] energy intake,[112] carbohydrate intake,[96,101,113] total fat intake,[66,114] Western dietary pattern,[108] meat intake,[108] intake of fried foods,[108] skipping breakfast,[115] heavy alcohol consumption,[116] abstention from alcohol use,[96] parental history of DM,[66] long-term stress at work,[117] pediatric metabolic syndrome,[66] obesity or BMI,[69,76,80,114,118] childhood obesity,[119] intra-abdominal fat,[120] gain in weight or BMI,[103,114] weight fluctuation,[121] heart rate,[122] homeostasis model assessment,[123,124] fasting insulin,[123] 2-hour insulin,[123] proinsulin,[123] oxidized LDL-C,[124] uric acid,[125,126] γ-glutamyltransferase,[125,127,128] alanine transaminase,[125,127,129,130] plasminogen activator inhibitor-1,[131] aldosterone,[131] leptin,[132] ferritin,[133] CRP,[134,135] adipocyte–fatty acid binding protein,[136] testosterone and sex hormone–binding globulin,[137,138] matrix metalloproteinase 9,[139] active periodontitis,[140] and urinary bisphenol A levels.[141]

- The following factors have been reported as being inversely associated with incident metabolic syndrome, defined by 1 of the major definitions, in prospective or retrospective cohort studies: muscular strength,[142] increased PA or physical fitness,[101,143] aerobic training,[144] moderate alcohol intake,[74,80] fiber intake,[145] white fish intake,[146] Mediterranean diet,[147] dairy consumption,[108] consumption of fermented milk with *Lactobacillus plantarum*,[148] hot tea consumption (but not sugar-sweetened iced tea),[149] vitamin D intake,[150,151] intake of tree nuts,[152] avocado intake,[153] potassium intake,[154] ability to interpret nutrition labels,[99] insulin sensitivity,[123] ratio of aspartate aminotransferase to alanine transaminase,[129] total testosterone,[120,123,155] serum 25-hydroxyvitamin D,[156] sex hormone–binding globulin,[120,123,155] and Δ5-desaturase activity.[157]
- In the DESIR cohort, metabolic syndrome was associated with an unfavorable hemodynamic profile, including increased brachial central pulse pressure and increase pulse pressure amplification, compared with similar individuals with isolated hypertension but without metabolic syndrome.[158] In MESA, metabolic syndrome was associated with major and minor ECG abnormalities, although this varied by sex.[159] Metabolic syndrome is associated with reduced heart rate variability and altered cardiac autonomic modulation in adolescents.[160]
- Individuals with metabolic syndrome have a higher degree of endothelial dysfunction than individuals with a similar burden of traditional cardiovascular risk factors.[161] Metabolic syndrome is associated with increased thrombosis, including increased resistance to aspirin[162] and clopidogrel loading.[163]
- In modern imaging studies using echocardiography, magnetic resonance imaging, cardiac CT, and positron emission tomography, metabolic syndrome has been shown to be closely related to increased epicardial adipose tissues,[164] regional neck fat distribution,[165] increased visceral fat in other locations,[166] high-risk coronary plaque features including increased necrotic core,[167] impaired coronary flow reserve,[168] abnormal indices of LV strain,[169] LV diastolic dysfunction,[170] LV dyssynchrony,[171] and subclinical right ventricular dysfunction.[172]
- In >6 years of follow-up in the ARIC Study, 1970 individuals (25%) developed metabolic syndrome, and compared with the normal-weight group (BMI <25 kg/m^2), the ORs of developing metabolic syndrome were 2.81 (95% CI, 2.50–3.17) and 5.24 (95% CI, 4.50–6.12) for the overweight (BMI 25–30 kg/m^2) and obese (BMI ≥30 kg/m^2) groups, respectively. Compared with the lowest quartile of leisure-time PA, the ORs of developing metabolic syndrome were 0.80 (95% CI, 0.71–0.91) and 0.92 (95% CI, 0.81–1.04) for people in the highest and middle quartiles, respectively.[173]

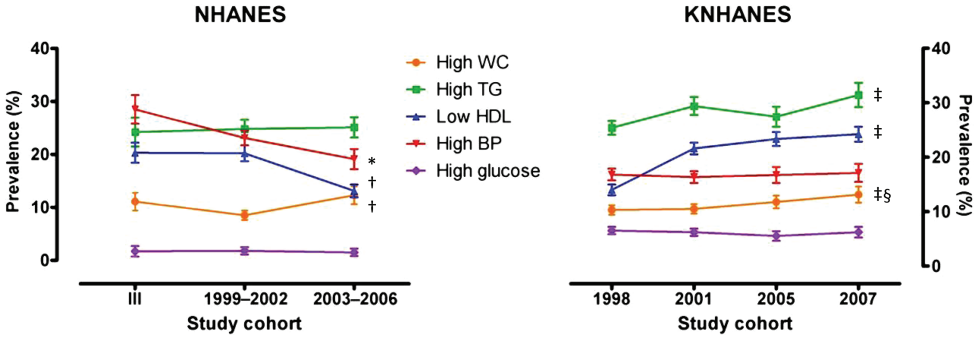

Chart 11-1. Secular trend of metabolic syndrome components in the US National Health and Nutrition Examination Survey (NHANES) and the Korean NHANES (KNHANES) cohorts over the past decade. BP indicates blood pressure; HDL, high-density lipoprotein cholesterol; TG, triglycerides; and WC, waist circumference. [a]Significant difference between NHANES 2003 to 2006 and NHANES III. [b]Significant difference between NHANES 2003 to 2006 and NHANES 1999 to 2002. [c]Significant difference between KNHANES 2007 and KNHANES 1998. [d]Significant difference between KNHANES 2007 and KNHANES 2001. Reprinted from Lim et al[15] with permission from the publisher.

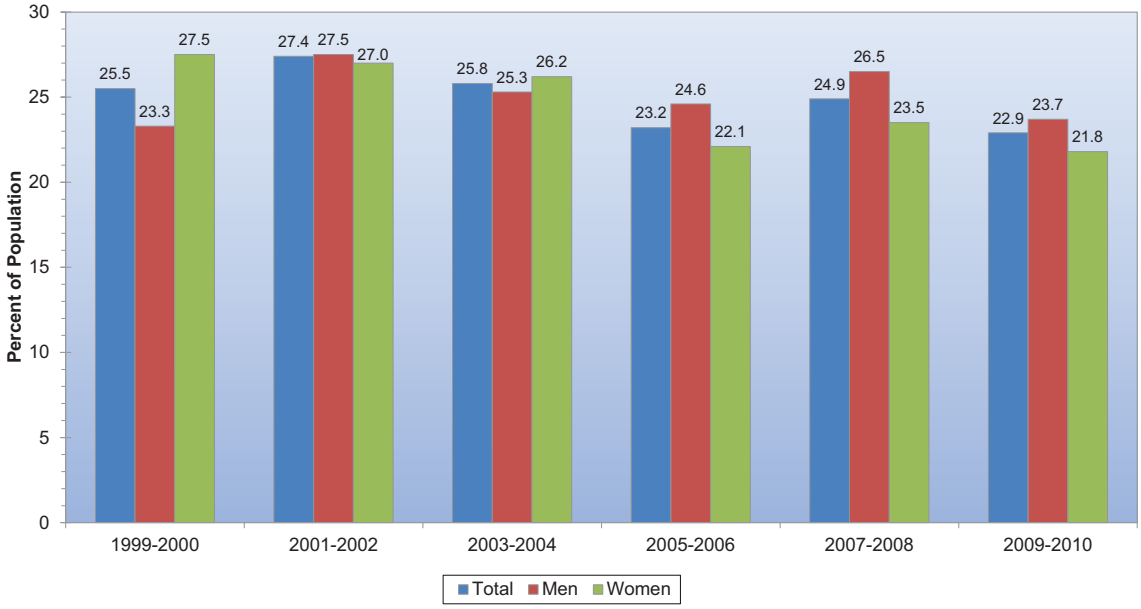

Chart 11-2. Age-adjusted prevalence of metabolic syndrome in the United States, National Health and Nutrition Examination Survey 1999 to 2010. Data derived from Beltrán-Sánchez et al.[24]

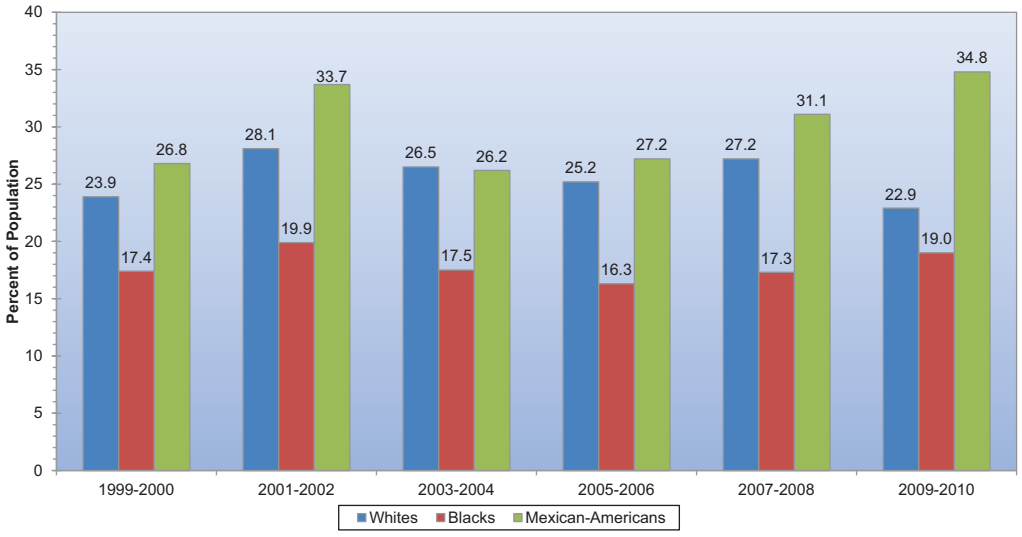

Chart 11-3. Age-adjusted prevalence of metabolic syndrome among men by race, National Health and Nutrition Examination Survey 1999 to 2010. Data derived from Beltrán-Sánchez et al.[24]

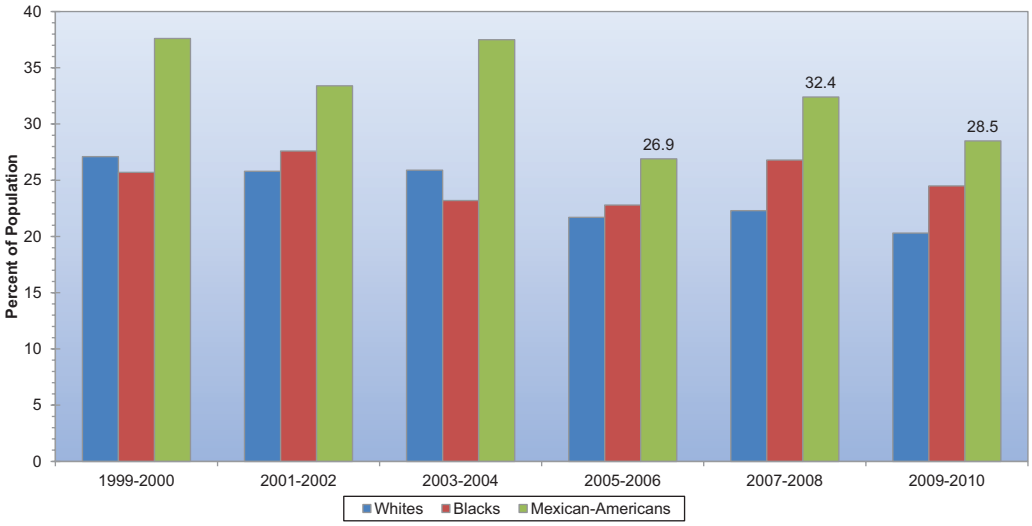

Chart 11-4. Age-adjusted prevalence of metabolic syndrome among women by race, National Health and Nutrition Examination Survey 1999 to 2010. Data derived from Beltrán-Sánchez et al.[24]

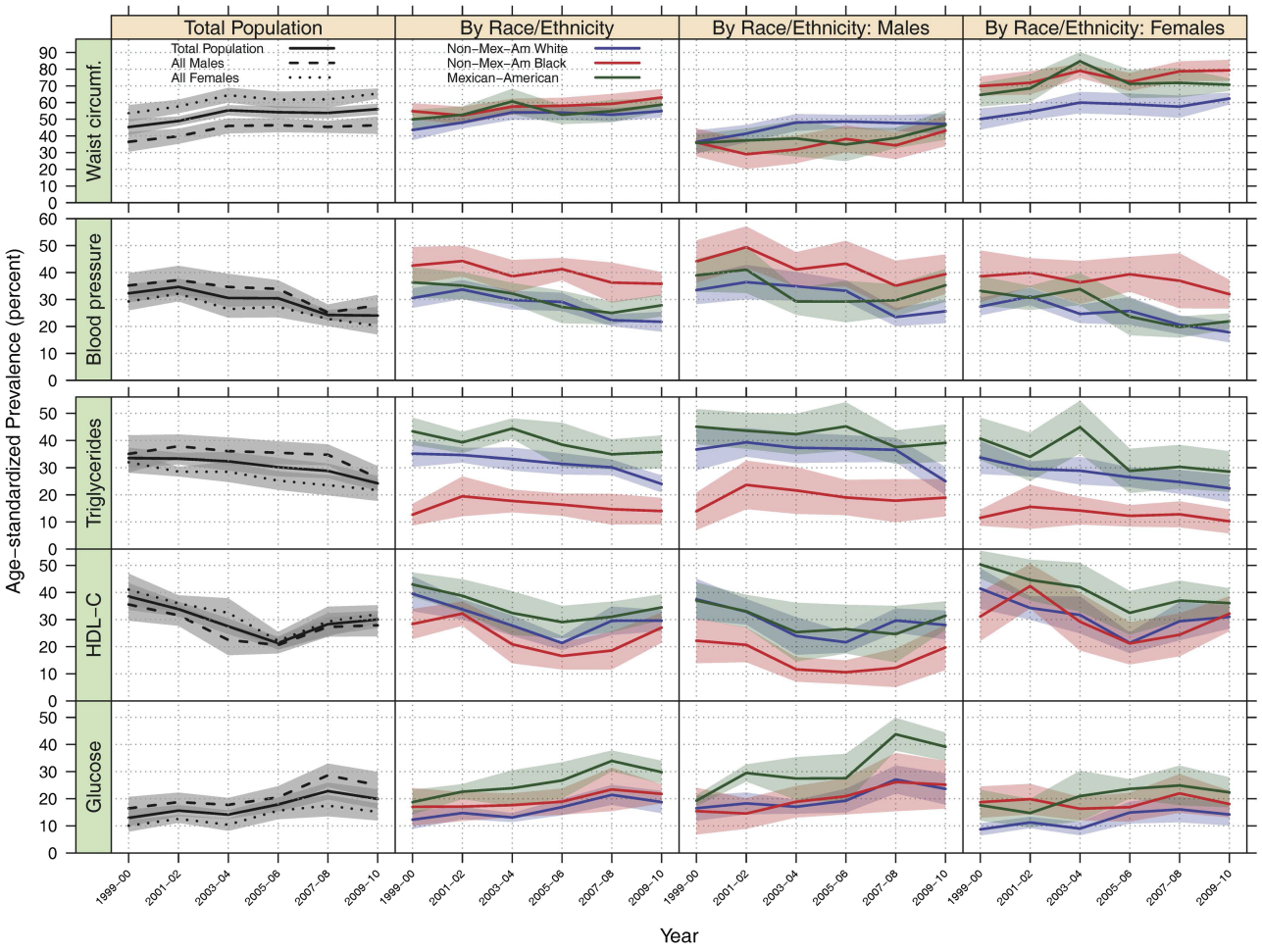

Chart 11-5. Prevalence and trends of the 5 components of metabolic syndrome in the adult US population (≥20 years old), 1999 to 2010, by sex (**first column**), race/ethnicity (**second column**), and race/ethnicity and sex (**third and fourth columns**). HDL-C indicates high-density lipoprotein cholesterol; Mex-Am, Mexican American; and Waist circumf., waist circumference. Shaded areas represent 95% confidence intervals. Reprinted from Beltrán-Sánchez et al[24] with permission from Elsevier. Copyright © 2013.

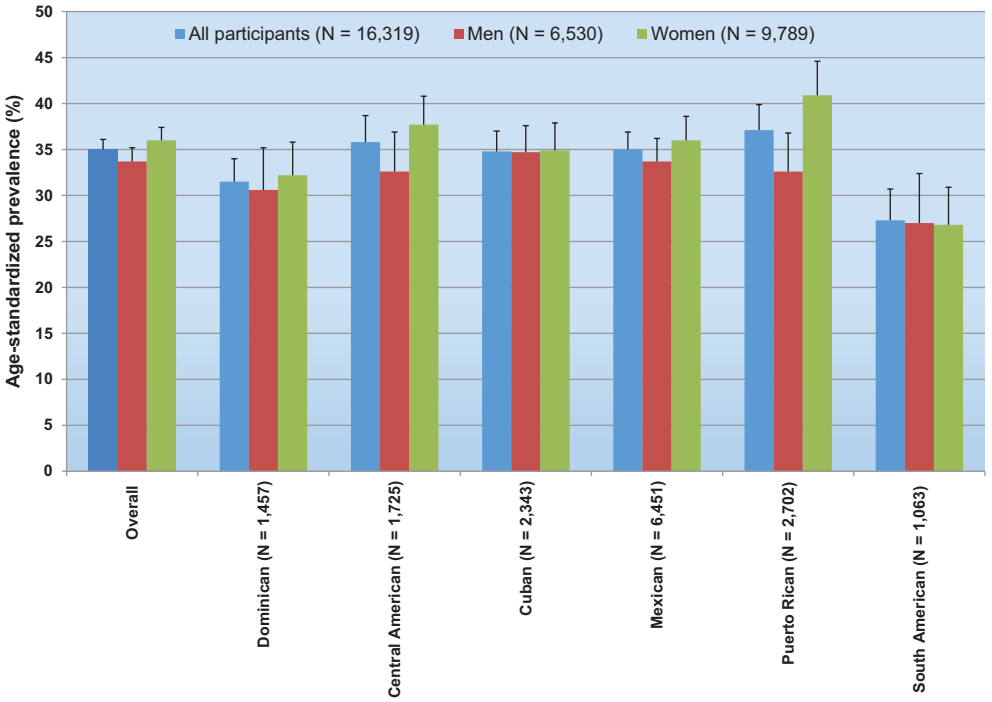

Chart 11-6. Age-standardized prevalence of metabolic syndrome by sex and Hispanic/Latino background, 2008 to 2011. Source: Hispanic Community Health Study/Study of Latinos.[27] Values were weighted for survey design and nonresponse and were age standardized to the population described by the 2010 US census.

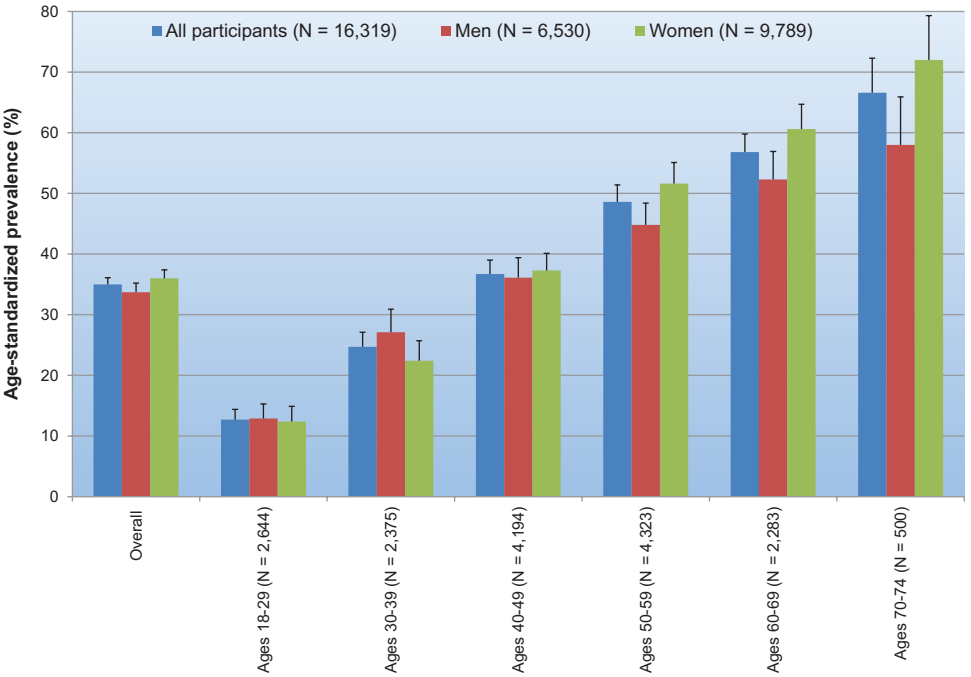

Chart 11-7. Age-standardized prevalence of metabolic syndrome by age and sex in Hispanics/Latinos, 2008 to 2011. Source: Hispanic Community Health Study/Study of Latinos.[27] Values were weighted for survey design and nonresponse and were age standardized to the population described by the 2010 US census.

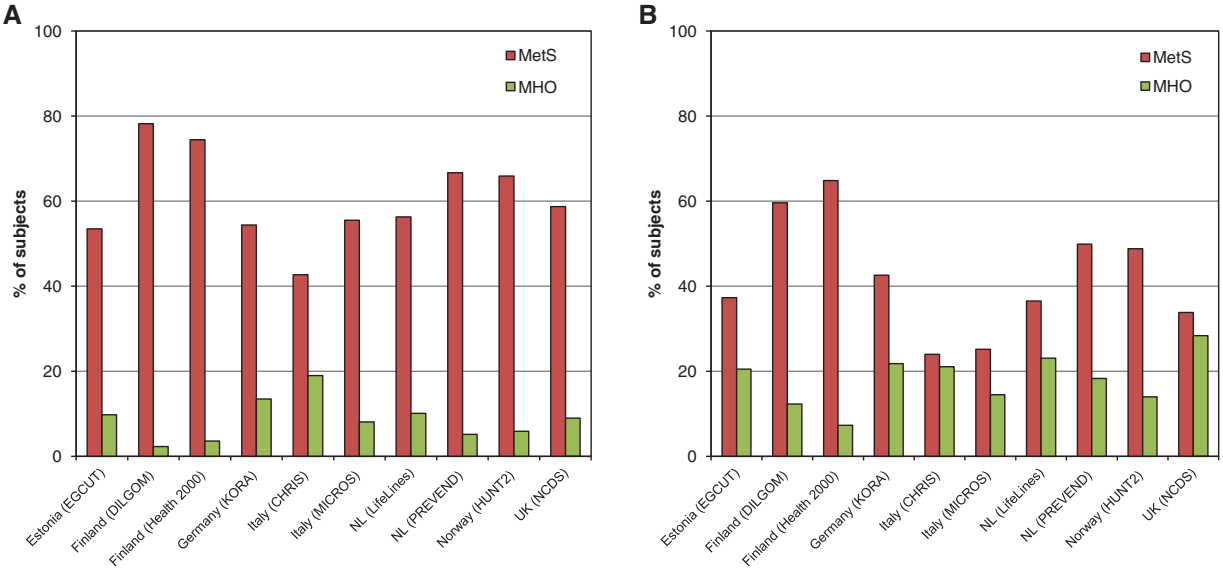

Chart 11-8. Age-standardized prevalence of metabolic syndrome (MetS) and metabolically healthy obesity (MHO) among obese (body mass index ≥30 kg/m^2) men (**A**) and women (**B**) in different cohorts. CHRIS indicates Collaborative Health Research in South Tyrol Study; DILGOM, Dietary, Lifestyle, and Genetics Determinants of Obesity and Metabolic Syndrome; EGCUT, Estonian Genome Center of the University of Tartu; HUNT2, Nord-Trøndelag Health Study; KORA, Cooperative Health Research in the Region of Augsburg; MICROS, Microisolates in South Tyrol Study; NCDS, National Child Development Study; NL, the Netherlands; and PREVEND, Prevention of Renal and Vascular End-Stage Disease. Reprinted from van Vliet-Ostaptchouket et al.[61] Copyright © 2014, BioMed Central.

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12. Chronic Kidney Disease

ICD-10 N18.0. See Tables 12-1 through 12-3.

End-Stage Renal Disease

Prevalence, Incidence, and Risk

(See Tables 12-1 and 12-2.)

ESRD is a condition that is most commonly associated with DM or HBP, occurs when the kidneys are functioning at a very low level, and is currently defined as the receipt of chronic renal replacement treatment such as hemodialysis, peritoneal dialysis, or kidney transplantation. The ESRD population increased more than 4-fold between the 1970s, when Medicare began providing reimbursement for ESRD treatment, and 2006.

- Data from the 2014 annual report of the US Renal Data System showed that on December 31, 2012, there were 636 905 prevalent cases of ESRD in the United States, with 70% of these prevalent cases being treated with hemodialysis.[1]
- In 2012, 114 813 new cases of ESRD were reported. Among those with known demographic information, 98 954 new patients began ESRD therapy with hemodialysis and 9175 with peritoneal dialysis, and 2803 received a preemptive kidney transplant.[1]

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Abbreviations Used in Chapter 12

ACC	American College of Cardiology
ACTION	Acute Coronary Treatment and Intervention Outcomes Network
AF	atrial fibrillation
AHA	American Heart Association
AMI	acute myocardial infarction
BMI	body mass index
BP	blood pressure
CHD	coronary heart disease
CHF	congestive heart failure
CI	confidence interval
CKD	chronic kidney disease
CVD	cardiovascular disease
DM	diabetes mellitus
eGFR	estimated glomerular filtration rate
ESRD	end-stage renal disease
GFR	glomerular filtration rate
HBP	high blood pressure
HF	heart failure
HR	hazard ratio
ICD-10	*International Classification of Diseases, 10th Revision*
JNC V	fifth report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure
MI	myocardial infarction
PAD	peripheral arterial disease
RR	relative risk
SBP	systolic blood pressure

- In 2012, there were 186 303 individuals in the United States who had received a kidney transplant.[1]
- The incidence rate of new cases of ESRD declined since 2006. The incidence rate was 9% lower in 2012 than in 2006. However, the number of people with prevalent ESRD is continuing to increase in the United States.[1]
- Data from a large cohort of insured patients showed that in addition to established risk factors for ESRD, lower hemoglobin levels, higher serum uric acid levels, self-reported history of nocturia, and family history of kidney disease are independent risk factors for ESRD.[2]
- Data from a large insured population revealed that among adults with a GFR >60 mL·min^{-1}·1.73 m^{-2} and no evidence of proteinuria or hematuria at baseline, risks for ESRD increased dramatically with higher baseline BP level, and in this same patient population, BP-associated risks were greater in men than in women and in blacks than in whites.[3]
- SBP maintains a strong and graded association with increased ESRD risk among the general population and individuals with CKD.[4,5]
- Results from a large community-based population showed that higher BMI was associated with an increased risk of ESRD.[6] In a separate study, the association between BMI and ESRD was reported to be modified by metabolic risk factors, and a strong association was present between metabolic syndrome and ESRD risk independent of BMI.[7]
- In 2012, ESRD incidence rates varied more than 15-fold by country, ranging from 25 to 467 new ESRD patients per million population.

Age, Sex, Race, and Ethnicity

- Treatment of ESRD is more common in men than in women.[1]
- Blacks, Hispanics, Asian Americans, and Native Americans have significantly higher rates of ESRD than do whites/Europeans. Blacks represent nearly one third of treated patients with ESRD.
- Compared with white patients with similar levels of kidney function, black patients are much more likely to progress to ESRD and are on average 10 years younger when they reach ESRD.[8,9]
- The higher incidence of ESRD among blacks than whites is explained in part by the higher prevalence of albuminuria in this population. However, even after controlling for major ESRD risk factors, blacks have a higher risk of ESRD than whites.

Chronic Kidney Disease

Prevalence

- CKD, defined as reduced GFR, excess urinary protein excretion, or both, is a serious health condition and a worldwide public health problem. The incidence and prevalence of CKD are increasing in the United States and are associated with poor outcomes and a high cost to the US healthcare system. Controversy exists about whether CKD itself independently causes incident CVD, but it is clear that people with CKD, as well as those with ESRD, represent a population at very high risk for CVD events. In fact, individuals with CKD are more likely to die of CVD than to transition to ESRD.

- The National Kidney Foundation Kidney Disease Outcome Quality Initiative developed guidelines in 2002 that provided a standardized definition for CKD.[10] These guidelines were updated in 2012, and the definition of CKD now includes both eGFR and albuminuria.
- According to the US Renal Data System 2014 annual data report[1]:
  - —In 2007 to 2012, the prevalence of CKD (stages 1–5) was 13.6%.
  - —The prevalence of stage 1 CKD (eGFR ≥90 mL·min^{-1}·1.73 m^{-2} with kidney damage, ie, presence of albuminuria) is 4.2%.
  - —The prevalence of stage 2 CKD (eGFR 60–89 mL·min^{-1}·1.73 m^{-2} with kidney damage) is 3.0%.
  - —The prevalence of stage 3 CKD (eGFR 30–59 mL·min^{-1}·1.73 m^{-2}) is 5.9%.
  - —The prevalence of stages 4 and 5 CKD (eGFR <30 mL·min^{-1}·1.73 m^{-2}) is 0.6%.
- From 1988 through 1994 to 2005 through 2010, the prevalence of CKD has increased ≈10%. This increase has occurred primarily among individuals with stage 3 CKD (from 4.5% to 6.0%).[1]
- More than 26 million people (13%) in the United States have CKD,[12] and >80% of individuals with CKD are unaware of this diagnosis.[13,14]
- For US adults aged 30 to 49, 50 to 64, and ≥65 years with no CKD at baseline, the residual lifetime incidences of CKD are 54%, 52%, and 42%, respectively. The prevalence of CKD in adults ≥30 years of age is projected to increase from 13.2% currently to 14.4% in 2020 and 16.7% in 2030.[15]
- In 2012, 10.4% of Medicare beneficiaries ≥65 years of age in the United States had recognized CKD.

Demographics

- The prevalence of CKD was higher with older age, as follows[1]:
  - —5.7% for those 20 to 39 years of age
  - —8.9% for those 40 to 59 years of age
  - —33.2% for those ≥60 years of age
- CKD prevalence was higher among those with DM (39.2%) and hypertension (31.0%) than among those without these chronic conditions.[1]
- Among US adults ≥80 years of age, the prevalence of an eGFR <60 mL·min^{-1}·1.73 m^{-2} increased from 40.5% in 1988 to 1994 to 49.9% and 51.2% in 1999 to 2004 and 2005 to 2010, respectively. The prevalence of albuminuria (albumin-to-creatinine ratio ≥30 mg/g) was 30.9%, 33.0%, and 30.6% in 1988 to 1994, 1999 to 2004, and 2005 to 2010, respectively.[16,17]
- In 2007 to 2012, the prevalence of CKD was higher at older age, was higher among women than men, and was similar among non-Hispanic whites and non-Hispanic blacks.[1]

Risk Factors

- Many traditional CVD risk factors are also risk factors for CKD, including older age, male sex, hypertension, DM, smoking, and family history of CVD.
- Recent evidence suggests that BMI is associated with worsening CKD. In a cohort of 652 African American individuals with hypertensive nephrosclerosis, BMI was independently associated with urine total protein and albumin excretion.[18]
- In addition, both the degree of CKD (ie, eGFR) and urine albumin are strongly associated with the progression from CKD to ESRD. Furthermore, urine albumin level is associated with progression to CKD across all levels of reduced eGFR.[19]
- Other risk factors include systemic conditions such as autoimmune diseases, systemic infections, and drug exposure, as well as anatomically local conditions such as urinary tract infections, urinary stones, lower urinary tract obstruction, and neoplasia. Even after adjustment for these risk factors, excess CVD risk remains.[20]

ESRD/CKD and CVD

(See Table 12-3.)

- CVD is the leading cause of death among those with ESRD, although the specific cardiovascular cause of death may be more likely to be arrhythmic than an AMI, end-stage HF, or stroke. CVD mortality is 5 to 30 times higher in dialysis patients than in subjects from the general population of the same age, sex, and race.[21,22]
  - —Individuals with less severe forms of kidney disease are also at significantly increased CVD risk independent of typical CVD risk factors.[23]
  - —CKD is a risk factor for recurrent CVD events.[24]
  - —CKD is also a risk factor for AF.[25]
- Studies from a broad range of cohorts demonstrate an association between reduced eGFR and elevated risk of CVD, CVD outcomes, and all-cause death[23,26–31] that appears to be largely independent of other known major CVD risk factors.
- Any degree of albuminuria, starting below the microalbuminuria cut point, has been shown to be an independent risk factor for cardiovascular events, CHF hospitalization, PAD, and all-cause death in a wide variety of cohorts.[32–37]
- A recent meta-analysis of 21 published studies of albuminuria involving 105 872 participants (730 577 person-years) from 14 studies with urine albumin-to-creatinine ratio measurements and 1 128 310 participants (4 732 110 person-years) from 7 studies with urine dipstick measurements showed that excess albuminuria or proteinuria is independently associated with a higher risk of CVD and all-cause mortality.[38]
- In a study of 1.3 million people, the risk for MI was 18.5 per 1000 person-years for those with a history of MI, 6.9 per 1000 person-years for those with CKD but no history of MI or DM, and 5.4 per 1000 person-years among those without MI or CKD but with DM.[39]
- One potential explanation for the higher CVD event rate in patients with CKD is the low uptake of standard therapies for patients presenting with MI. In a recent analysis from the ACTION registry, patients presenting with CKD had a substantially higher mortality rate. In addition, patients with CKD were less likely to receive standard therapies for the treatment of MI.[40]

- The majority of US adults with CKD stages 3 to 5 (79.8%) and stages 1 and 2 (59.1%) have ≥2 cardiovascular risk factors. Compared with those without CKD, US adults with stages 1 to 2 and stages 3 to 5 CKD are more likely to have hypertension (57.8% and 85.6%, respectively, for stage 1–2 and stage 3–5 CKD versus 31.7% for no CKD) and DM (29.7% and 30.7% versus 8.0%) but not hypercholesterolemia (72.2% and 74.3% versus 69.8%).[41]
- Individuals with versus without predialysis CKD are more likely to have a history of CVD (28.4% versus 6.0%), CHD (19.6% versus 4.3%), stroke (10.3% versus 1.9%), and HF (9.7% versus 1.2%).[42]
- Lower eGFR (45 versus 95 $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$) has been associated with an increased risk for ischemic (HR, 1.30; 95% CI, 1.01–1.68) but not hemorrhagic stroke (HR, 0.92; 95% CI, 0.47–1.81), respectively. Albuminuria (albumin-to-creatinine ratio of 300 versus 5 mg/g) is associated with both ischemic and hemorrhagic stroke (HR, 1.62 [95% CI, 1.27–2.07] and 2.57 [95% CI, 1.37–4.83], respectively).[43]
- In a nationwide US cohort that included 4726 participants with CKD, 2366 (50%) were taking statins, and statins were recommended for 1984 participants (42%) according to the ACC/AHA guidelines but were not being used.[44] The Pooled Cohort risk equations were well calibrated (Hosmer-Lemeshow χ^2=2.7, P=0.45), with moderately good discrimination (C index, 0.71; 95% CI, 0.65–0.77).[44]
- CKD is associated with risk for recurrent CHD events that approximates or is larger than that for DM, cigarette smoking, or the metabolic syndrome.[45]
- The association of CKD with CVD risk has been reported to be similar across age, race, and sex subgroups.[46]

Cost: ESRD

- The total annual cost of treating ESRD in the United States was $28.6 billion in 2012, which represents nearly 6% of the total Medicare budget.[1]
- Among US Medicare beneficiaries, healthcare costs associated with stage 1,2, 3, and 4 CKD, respectively, compared with no CKD were $1600 (95% CI, –$900 to $3870), $1700 (95% CI, $530–$2840), $3500 (95% CI, $1780–$4620), and $12 700 (95% CI, $6000–$49 650).[47]

Cystatin C: Kidney Function and CVD

- Serum cystatin C, another marker of kidney function, has been proposed to be a more sensitive indicator of kidney function than serum creatinine and creatinine-based estimating formulas at higher levels of GFR. It is a low-molecular-weight protein produced at a constant rate by all nucleated cells and appears not to be affected significantly across age, sex, and levels of muscle mass. Cystatin C is excreted by the kidneys, filtered through the glomerulus, and nearly completely reabsorbed by proximal tubular cells.[48] Several equations have been proposed using cystatin C alone and in combination with serum creatinine to estimate kidney function.[49,50]

All-Cause Mortality

- Elevated levels of cystatin C have been shown to be associated with increased risk for all-cause mortality in studies from a broad range of cohorts.[51–53]
- In addition to GFR and urine albumin-to-creatinine ratio, cystatin C provides incremental information for the prediction of ESRD and mortality.
  - —The addition of cystatin C to the combination of creatinine and albumin-to-creatinine ratio resulted in a significant improvement in the prediction of both all-cause mortality and the development of ESRD.[54,55]

Cardiovascular Disease

- Data from a large national cohort found higher values of cystatin C to be associated with prevalent stroke, angina, and MI,[56] as well as higher BMI.[57]
- Elevated cystatin C was an independent risk factor for HF,[58,59] PAD events,[60] clinical atherosclerosis, and subclinical measures of CVD in older adults,[61] as well as for cardiovascular events among those with CHD.[51,62]
- In several diverse cohorts, elevated cystatin C has been found to be associated with CVD-related mortality,[53,63,64] including sudden cardiac death.[65]

Table 12-1. BP and the Adjusted Risk of ESRD Among 316 675 Adults Without Evidence of Baseline Kidney Disease

JNC V BP Category	Adjusted RR (95% CI)
Optimal	1.00 (Reference)
Normal, not optimal	1.62 (1.27–2.07)
High normal	1.98 (1.55–2.52)
Hypertension	
Stage 1	2.59 (2.07–3.25)
Stage 2	3.86 (3.00–4.96)
Stage 3	3.88 (2.82–5.34)
Stage 4	4.25 (2.63–6.86)

BP indicates blood pressure; CI, confidence interval; ESRD, end-stage renal disease; JNC V, fifth report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; and RR, relative risk.

Table 12-2. Multivariable Association Between BMI and Risk of ESRD Among 320 252 Adults

BMI, kg/m^2	Adjusted RR (95% CI)
18.5–24.9 (Normal weight)	1.00 (Reference)
25.0–29.9 (Overweight)	1.87 (1.64–2.14)
30.0–34.9 (Class I obesity)	3.57 (3.05–4.18)
35.0–39.9 (Class II obesity)	6.12 (4.97–7.54)
≥40.0 (Extreme obesity)	7.07 (5.37–9.31)

BMI indicates body mass index; CI, confidence interval; ESRD, end-stage renal disease; and RR, relative risk.

Table 12-3. Adjusted HR for Death of Any Cause, Cardiovascular Events, and Hospitalization Among 1 120 295 Ambulatory Adults, According to eGFR*

	Adjusted HR (95% CI)		
eGFR, mL·min^{-1}·1.73 m^{-2}	Death of Any Cause	Any Cardiovascular Event	Any Hospitalization
≥60†	1.00	1.00	1.00
45–59	1.2 (1.1–1.2)	1.4 (1.4–1.5)	1.1 (1.1-1.1)
30–44	1.8 (1.7–1.9)	2.0 (1.9–2.1)	1.5 (1.5-1.5)
15–29	3.2 (3.1–3.4)	2.8 (2.6–2.9)	2.1 (2.0–2.2)
<15	5.9 (5.4–6.5)	3.4 (3.1–3.8)	3.1 (3.0–3.3)

CI indicates confidence interval; eGFR, estimated glomerular filtration rate; and HR, hazard ratio.

*The analyses were adjusted for age, sex, income, education, use or nonuse of dialysis, and presence or absence of prior coronary heart disease, prior chronic heart failure, prior ischemic stroke or transient ischemic attack, prior peripheral arterial disease, diabetes mellitus, hypertension, dyslipidemia, a serum albumin level of ≤3.5 g/dL, dementia, cirrhosis or chronic liver disease, chronic lung disease, documented proteinuria, and prior hospitalizations.

†This group served as the reference group.

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13. Total Cardiovascular Diseases

ICD-9 390 to 459, ICD-10 I00 to I99; see Glossary (Chapter 27) for details and definitions.

See Tables 13-1 through 13-3 and Charts 13-1 through 13-20.

Prevalence

(See Table 13-1 and Chart 13-1.)

An estimated 85.6 million American adults (>1 in 3) have ≥1 types of CVD. Of these, 43.7 million are estimated to be ≥60 years of age. Total CVD includes diseases listed in the bullet points below. Because of overlap across conditions, it is not possible to add these conditions to arrive at a total.

- HBP—80.0 million (defined as SBP ≥140 mm Hg and/or DBP ≥90 mm Hg, use of antihypertensive medication, or being told at least twice by a physician or other health professional that one has HBP).
- CHD—15.5 million
  - —MI (heart attack)—7.6 million
  - —AP (chest pain)—8.2 million
  - —HF—5.7 million
  - —Stroke (all types)—6.6 million
- The following age-adjusted race-ethnicity prevalence estimates from the NHIS, NCHS are for diagnosed conditions for people ≥18 years of age in 2014[1]:
  - —Among non-Hispanic Whites, 11.1% have HD (includes CHD, AP, MI, or any other heart condition or disease), 5.6% have CHD (includes CHD, AP, or MI), 23.5% have hypertension, and 2.3% have had a stroke.
  - —Among blacks or African Americans, 10.3% have HD, 5.5% have CHD, 33.0% have hypertension, and 4.0% have had a stroke.
  - —Among Hispanics or Latinos (predominately Mexican Americans in this sample), 7.8% have HD, 4.9% have CHD, 22.9% have hypertension, and 2.4% have had a stroke.
  - —Among Asians, 6.0% have HD, 3.3% have CHD, 19.5% have hypertension, and 1.5% have had a stroke.*
  - —Among American Indians or Alaska Natives, 13.7% have HD,* 6.0% have CHD,* 26.4% have hypertension, and 3.0% have had a stroke.*
  - —Among native Hawaiians or other Pacific Islanders, 19.1% have HD,* 6.9% have CHD,* and 36.4% have hypertension.* The statistics for stroke for this group are not shown because of unreliability.*
- Asian Indian adults (9%) are ≈2-fold more likely than Korean adults (4%) to have ever been told they have HD, based on data for 2004 to 2006.[2]
- By 2030, 43.9% of the US population is projected to have some form of CVD (unpublished AHA tabulation, based on methodology described by Heidenreich et al[3]).
- The AHA's 2020 Impact Goals are to improve the cardiovascular health of all Americans by 20% while reducing deaths attributable to CVDs and stroke by 20%.[4]

*Prevalence is statistically unreliable (relative SE >30% and <50%). The statistic not shown has a relative SE >50%.

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Abbreviations Used in Chapter 13

AHA	American Heart Association	*ICD-9*	*International Classification of Diseases, 9th Revision*
AMI	acute myocardial infarction	*ICD-10*	*International Classification of Diseases, 10th Revision*
AP	angina pectoris	LDL-C	low-density lipoprotein cholesterol
ARIC	Atherosclerosis Risk in Communities	MEPS	Medical Expenditure Panel Survey
BMI	body mass index	MESA	Multi-Ethnic Study of Atherosclerosis
BP	blood pressure	MI	myocardial infarction
CDC	Centers for Disease Control and Prevention	NAMCS	National Ambulatory Medical Care Survey
CHD	coronary heart disease	NCHS	National Center for Health Statistics
CHF	congestive heart failure	NH	non-Hispanic
CLRD	chronic lower respiratory disease	NHAMCS	National Hospital Ambulatory Medical Care Survey
CVD	cardiovascular disease	NHANES	National Health and Nutrition Examination Survey
DBP	diastolic blood pressure	NHDS	National Hospital Discharge Survey
DM	diabetes mellitus	NHHCS	National Home and Hospice Care Survey
ED	emergency department	NHIS	National Health Interview Survey
FHS	Framingham Heart Study	NHLBI	National Heart, Lung, and Blood Institute
HBP	high blood pressure	PA	physical activity
HD	heart disease	RR	relative risk
HDL	high-density lipoprotein	SBP	systolic blood pressure
HF	heart failure	SE	standard error
HIV	human immunodeficiency virus	WONDER	Wide-ranging Online Data for Epidemiologic Research

Mortality

(See Tables 13-1 through 13-3 and Charts 13-2 through 13-17.)

ICD-10 I00 to I99 for CVD; C00 to C97 for cancer; C33 to C34 for lung cancer; C50 for breast cancer; J40 to J47 for CLRD; G30 for Alzheimer disease; E10 to E14 for DM; and V01 to X59 and Y85 to Y86 for accidents.

- In every year since 1900 except 1918, CVD accounted for more deaths than any other major cause of death in the United States.[5,6]
- Based on 2013 mortality data[6]:
  - —CVD as the listed underlying cause of death accounted for 30.8% (800 937) of all 2 596 993 deaths, or ≈1 of every 3 deaths in the United States. CVD any-mentions (1 402 204 deaths in 2013) constituted 54.0% of all deaths that year (NHLBI; NCHS public use data files).
  - —On average, ≈2200 Americans die of CVD each day, an average of 1 death every 40 seconds.
  - —CVD currently claims more lives each year than cancer and CLRD combined.
  - —The death rate attributable to CVD was 222.9 per 100 000.
  - —The death rates were 269.8 for males and 184.8 for females. The rates were 270.6 for non-Hispanic white males, 356.7 for non-Hispanic black males, 197.4 for Hispanic males, 183.8 for non-Hispanic white females, 246.6 for non-Hispanic black females, and 136.4 for Hispanic females.
  - —From 2003 to 2013, death rates attributable to CVD declined 28.8%. In the same period, the actual number of CVD deaths per year declined by 11.7% (NHLBI tabulation).[7]
  - —Among other causes of death, cancer caused 584 881 deaths; CLRD, 149 205; accidents, 130 557; and Alzheimer disease, 84 767.
  - —The leading causes of death in women ≥65 years of age were diseases of the heart (No. 1), cancer (No. 2), CLRD (No. 3), and stroke (No. 4). In older men, they were diseases of the heart (No. 1), cancer (No. 2), CLRD (No. 3), and stroke (No. 4).
  - —CVD caused ≈1 death every 1 minute 20 twenty seconds among females, or 398 086 deaths. That represents approximately the same number of female lives that were claimed by cancer, CLRD, and DM combined (unpublished NHLBI tabulation). There were 40 861 deaths attributable to breast cancer in females; lung cancer claimed 70 542 females. Age-adjusted death rates for females were 20.8 for breast cancer and 35.5 for lung cancer. One in 4.7 females died of cancer, whereas 1 in 3.2 died of CVD. For comparison of specific types of cancer and CVD, 1 in 31.6 deaths of females was attributable to breast cancer, whereas 1 in 8.0 was attributable to CHD.
  - —Approximately 155 000 Americans who were <65 years of age died of CVD, and 35% of deaths attributed to CVD occurred before the age of 75 years, which is well below the average life expectancy of 78.8 years.
- If all forms of major CVD were eliminated, life expectancy could rise by almost 7 years. If all forms of cancer were eliminated, the estimated gain could be 3 years. According to the same study, the probability at birth of eventually dying of major CVD (*ICD-10* I00–I78) is 47%, and the chance of dying of cancer is 22%. Additional probabilities are 3% for accidents, 2% for DM (unrelated to CVD), and 0.7% for HIV.[8]
- A study of the decrease in US deaths attributable to CHD from 1980 to 2000 suggests that ≈47% of the decrease was attributable to increased use of evidence-based medical therapies for secondary prevention and 44% to changes in risk factors in the population attributable to lifestyle and environmental changes.[5]
- Analysis of data from NCHS was used to determine the number of disease-specific deaths attributable to all non-optimal levels of each risk factor exposure, by age and sex. In 2005, tobacco smoking and HBP were estimated to be responsible for 467 000 deaths, accounting for ≈1 in 5 or 6 deaths among US adults. Overweight/obesity and physical inactivity were each estimated to be responsible for nearly 1 in 10 deaths. High dietary salt, low dietary omega-3 fatty acids, and high dietary *trans* fatty acids were the dietary risks with the largest estimated excess mortality effects.[8]

Aftermath

- Among the estimated 45 million people with functional disabilities in the United States, HD, stroke, and hypertension are among the 15 leading conditions that caused those disabilities. Disabilities were defined as difficulty with activities of daily living or instrumental activities of daily living, specific functional limitations (except vision, hearing, or speech), and limitation in ability to do housework or work at a job or business.[9]

Awareness of Warning Signs and Risk Factors for CVD

- Surveys conducted every 3 years since 1997 by the AHA to evaluate trends in women's awareness, knowledge, and perceptions related to CVD found most recently (in 2012) that awareness of HD as the leading cause of death among women was 56%, 30% higher than in 1997 (P<0.001). Awareness among black and Hispanic women in 2012 was similar to that of white women in 1997; however, awareness rates in 2012 among black and Hispanic women remained well below that of white women. Awareness of heart attack signs remained low for all racial/ethnic and age groups surveyed during the same time.[10]

Disparities in CVD Risk Factors

(See Chart 13-18.)

- Analysis of several data sets by the CDC showed that in adults ≥18 years of age, disparities were common in all risk factors examined. In men, the highest prevalence of obesity (29.7%) was found in Mexican Americans who had completed a high school education. Black women with or without a high school education had a high prevalence of obesity (48.4%). Hypertension prevalence was high among blacks (41.2%) regardless of sex or educational status. Hypercholesterolemia was high among white and Mexican American men and white women regardless of educational status. CHD and stroke were inversely related to education,

income, and poverty status. Hospitalization for total HD and AMI was greater among men, but hospitalization for CHF and stroke was greater among women. Among Medicare enrollees, CHF hospitalization was higher among blacks, Hispanics, and American Indian/Alaska Natives than among whites, and stroke hospitalization was highest among blacks. Hospitalizations for CHF and stroke were highest in the southeastern United States. Life expectancy remains higher in women than in men and in whites than in blacks by ≈5 years. CVD mortality at all ages tended to be highest in blacks.[11]

- Analysis of >14 000 middle-aged participants in the ARIC study sponsored by the NHLBI showed that ≈90% of CVD events in black participants, compared with ≈65% in white participants, appeared to be explained by elevated or borderline risk factors. Furthermore, the prevalence of participants with elevated risk factors was higher in black participants; after accounting for education and known CVD risk factors, the incidence of CVD was identical in black and white participants. Although organizational and social barriers to primary prevention do exist, the primary prevention of elevated risk factors might substantially impact the future incidence of CVD, and these beneficial effects would likely be applicable not only for white but also for black participants.[12]
- Mortality data from the National Vital Statistics System from 2001 to 2010 show that the avoidable death rate among blacks was nearly twice that of whites.[13]
- Data from the MEPS 2004 Full-Year Data File showed that nearly 26 million US adults ≥18 years of age were told by a doctor that they had HD, stroke, or any other heart-related disease[14]:

  —Among those told that they had HD, 33.9% had a healthy weight compared with 39.3% who had never been told they had HD.

  —Among those ever told that they had indicators of HD, 18.3% continued to smoke.

  —More than 93% engaged in at least 1 recommended behavior for prevention of HD (not smoking, engaging in physical exercise regularly, and maintaining healthy weight): 75.5% engaged in 1 or 2; 18% engaged in all 3; and 6.5% did not engage in any of the recommended behaviors.

  —Age-based variations:

  - Moderate to vigorous PA ≥3 times per week varied according to age. Younger people (18–44 years of age) were more likely (59.9%) than those who were older (45–64 and ≥65 years of age, 55.3% and 48.5%, respectively) to engage in regular PA.
  - A greater percentage of those 18 to 44 years of age had a healthy weight (43.7%) than did those 45 to 64 years of age and ≥65 years of age (31.4% and 37.3%, respectively).
  - People ≥65 years of age were more likely to be nonsmokers (89.7%) than were people 18 to 44 years of age and 45 to 64 years of age (76.1% and 77.7%, respectively).

  —Race/ethnicity-based variations:

  - Non-Hispanic whites were more likely than Hispanics or non-Hispanic blacks to engage in moderate to vigorous PA (58.5% versus 51.4% and 52.5%, respectively).
  - Non-Hispanic whites were more likely to have maintained a healthy weight than were Hispanics or non-Hispanic blacks (39.8% versus 32.1% and 29.7%, respectively).
  - Hispanics were more likely to be nonsmokers (84.2%) than were non-Hispanic whites and non-Hispanic blacks (77.8% and 76.3%, respectively).

  —Sex-based variations:

  - Men were more likely to have engaged in moderate to vigorous PA ≥3 times per week than women (60.3% versus 53.1%, respectively).
  - Women were more likely than men to have maintained a healthy weight (45.1% versus 31.7%, respectively).
  - Data from the CDC's Vital and Health Statistics 2008 to 2010 showed that 82% of women did not currently smoke compared with 77.6% of men.[15]

  —Variations based on education level:

  - A greater percentage of adults with at least some college education engaged in moderate to vigorous PA ≥3 times per week (60.8%) than did those with a high school education or less than a high school education (55.3% and 48.3%, respectively).
  - A greater percentage of adults with at least some college education had a healthy weight (41.2%) than did those with a high school or less than high school education (36.2% and 36.1%, respectively).
  - There was a greater percentage of nonsmokers among those with a college education (85.5%) than among those with a high school or less than high school education (73.8% and 69.9%, respectively).

- Data from the CDC's Vital and Health Statistics 2008 to 2010 showed that smokers with family incomes below the poverty level were more than twice as likely as adults in the highest family income group to be current smokers (29.2% versus 13.9%, respectively) (CDC, NCHS, 2013).[15]
- A study of nearly 1500 participants in MESA found that Hispanics with hypertension, hypercholesterolemia, or DM who spoke Spanish at home (as a proxy of lower levels of acculturation) or had spent less than half a year in the United States had higher SBP, LDL-C, and fasting blood glucose, respectively, than Hispanics who were preferential English speakers and who had lived a longer period of time in the United States.[16]
- Recent findings from >15 000 Hispanics of diverse background demonstrated that a sizeable proportion of both men and women had major CVD risk factors, with higher prevalence among Puerto Rican subgroups and those with lower socioeconomic status and a higher level of acculturation.[17]

Family History of CVD

(See Chapter 7 for more detailed information.)

- A family history of CVD increases risk of CVD, with the largest increase in risk if the family member's CVD was premature.[18]

- There is consistent evidence from multiple large-scale prospective epidemiology studies for a strong and significant association of a reported family history of premature parental CHD with incident MI or CHD in offspring. In the FHS, the occurrence of a validated premature atherosclerotic CVD event in either a parent[19] or a sibling[20] was associated with an ≈2-fold elevated risk for CVD, independent of other traditional risk factors. Addition of a family history of premature CVD to a model that contained traditional risk factors provided improved prognostic value in the FHS.[19]
- Parental history of premature CHD is associated with increased burden of subclinical atherosclerosis in the coronary arteries and the abdominal aorta.[21,22]
- In the FHS, a parental history of validated HF was associated with a 1.7-fold higher risk of HF in offspring, after multivariable adjustment.[23]
- Despite the importance of family history, several barriers impede first-degree relatives of people with CVD from engaging in risk-reducing behaviors, such as few being aware of the specific health information from relatives necessary to develop a family history; in addition, there is an inappropriate risk perception or an underestimation of one's own sense of vulnerability.[24]

Impact of Healthy Lifestyle and Low Risk Factor Levels

(See Chapter 2 for more detailed statistics regarding healthy lifestyles and low risk factor levels.)

A number of studies suggest that prevention of risk factor development at younger ages may be the key to "successful aging," and they highlight the need for evaluation of the potential benefits of intensive prevention efforts at younger and middle ages once risk factors develop to increase the likelihood of healthy longevity.

- Approximately 80% of CVDs can be prevented through not smoking, eating a healthy diet, engaging in PA, maintaining a healthy weight, and controlling HBP, DM, and elevated lipid levels. The presence of a greater number of optimal cardiovascular health metrics is associated with a graded and significantly lower risk of total and CVD mortality.[25]
- Data from the Cardiovascular Lifetime Risk Pooling Project, which involved 18 cohort studies and combined data on 257 384 black men and women and white men and women, indicate that at 45 years of age, participants with optimal risk factor profiles had a substantially lower lifetime risk of CVD events than those with 1 major risk factor (1.4% versus 39.6% among men; 4.1% versus 20.2% among women). Having ≥2 major risk factors further increased lifetime risk to 49.5% in men and 30.7% in women.[26]
- In another study, FHS investigators followed up 2531 men and women who were examined between the ages of 40 and 50 years and observed their overall rates of survival and survival free of CVD to 85 years of age and beyond. Low levels of the major risk factors in middle age were associated with overall survival and morbidity-free survival to ≥85 years of age.[27]
- Data from the Chicago Heart Association Detection Project (1967–1973, with an average follow-up of 31 years) showed the following:
  - —In younger women (18–39 years of age) with favorable levels for all 5 major risk factors (BP, serum cholesterol, BMI, DM, and smoking), future incidence of CHD and CVD is rare, and long-term and all-cause mortality are much lower than for those who have unfavorable or elevated risk factor levels at young ages. Similar findings applied to men in this study.[28]
  - —Participants (18–64 years of age at baseline) without a history of MI were investigated to determine whether traditional CVD risk factors were similarly associated with CVD mortality in black and white men and women. In general, the magnitude and direction of associations were similar by race. Most traditional risk factors demonstrated similar associations with mortality in black and white adults of the same sex. Small differences were primarily in the strength and not the direction of the association.[29]
- Data from NHANES 2005 to 2010 showed that only 8.8% of adults complied with ≥6 heart-healthy behaviors. Of the 7 factors studied, healthy diet was the least likely to be achieved (only 22% of adults with a healthy diet).[25]
- Seventeen-year mortality data from the NHANES II Mortality Follow-Up Study indicated that the RR for fatal CHD was 51% lower for men and 71% lower for women with none of the 3 major risk factors (hypertension, current smoking, and elevated TC [≥240 mg/dL]) than for those with ≥1 risk factor. Had all 3 major risk factors not occurred, it is hypothesized that 64% of all CHD deaths among women and 45% of CHD deaths in men could have been avoided.[30]

Hospital Discharges, Ambulatory Care Visits, Home Healthcare Patients, Nursing Home Residents, and Hospice Care Discharges

(See Table 13-1 and Charts 13-19 and 13-20.)

- From 2000 to 2010, the number of inpatient discharges from short-stay hospitals with CVD as the first-listed diagnosis decreased from 6 294 000 to 5 802 000 (NHDS, NCHS, and NHLBI). In 2010, CVD ranked highest among all disease categories in hospital discharges (NHDS, NCHS, and NHLBI).
- In 2012, there were 69 184 000 physician office visits with a primary diagnosis of CVD (NCHS, NAMCS, NHLBI tabulation). In 2011, there were 4 359 000 ED visits and 8 505 000 hospital outpatient department visits with a primary diagnosis of CVD (NCHS, NHAMCS, NHLBI tabulation).
- Among the 1 459 900 home healthcare patients each day in 2007, CVD was the leading primary diagnosis; almost one fifth of home healthcare patients had a primary diagnosis of CVD at admission into home health care (18.3% or 267 300 residents) or at the time of interview (18.9% or 275 700 residents) (NCHS, NHHCS). The majority (62.9% or 918 900 patients) of home healthcare patients each day in 2007 had any diagnosis of CVD at the time of interview.[31]
- Among the 1 045 100 patients discharged from hospice in 2007, CVD was the primary diagnosis for 15.8% (or 165 100 discharges) at admission and 15.9% (or 165 700 discharges) at discharge. Half (50% or 523 000) of all hospice discharges had any diagnosis of CVD at the time of discharge.[31]

Operations and Procedures

(See Chapter 24 for detailed information.)

- In 2010, an estimated 7 588 000 inpatient cardiovascular operations and procedures were performed in the United States; 4.4 million were performed on males, and 3.2 million were performed on females (NHLBI tabulation of NHDS, NCHS).

Cost

(See Chapter 25 for detailed information.)

- The estimated direct and indirect cost of CVD for 2011 to 2012 is $316.6 billion (MEPS, NHLBI tabulation).
- By 2030, (2012$) total direct medical costs of CVD are projected to increase to ≈$918 billion (unpublished AHA tabulation based on methodology described by Heidenreich et al[3]).

Global Burden of CVD

(See Table 13-3.)

- CVD is the leading global cause of death, accounting for >17.3 million deaths per year in 2013,[32] a number that is expected to grow to >23.6 million by 2030.[33] Deaths attributable to ischemic HD increased by an estimated 41.7% from 1990 to 2013.[34]
- In 2013, CVD deaths represented 31% of all global deaths.[35]
- In 2011, data from the World Economic Forum found that CVD represented 50% of noncommunicable disease deaths.[34] CVD represents 37% of deaths of individuals under the age of 70 years that are attributable to noncommunicable diseases.[36]
- Eighty percent of CVD deaths take place in low- and middle-income countries and occur almost equally in men and women.[33]
- In May 2012, during the World Health Assembly, Ministers of Health agreed to adopt a global target to reduce premature (age 30–70 years) noncommunicable disease mortality 25% by 2025.[37] Targets for 6 risk factors (tobacco and alcohol use, salt intake, obesity, and raised BP and glucose) were also agreed on to address this goal. It is projected that if the targets are met, premature death attributable to CVDs in 2025 will be reduced by 34%, with 11.4 million and 15.9 million deaths delayed or prevented in those aged 30 to 69 years and ≥70 years, respectively.[38]
- In 2010, the estimated global cost of CVD was $863 billion, and it is estimated to rise to $1044 billion by 2030.[34]

Table 13-1. Cardiovascular Diseases

Population Group	Prevalence, 2012: Age ≥20 y	Mortality, 2013: All Ages*	Hospital Discharges, 2010: All Ages	Cost, 2012
Both sexes	85 600 000 (35.0%)	800 937	5 802 000	$316.6 Billion
Males	41 800 000 (36.4%)	402 851 (50.3%)†	3 021 000	…
Females	43 800 000 (33.7%)	398 086 (49.7%)†	2 781 000	…
NH white males	36.1%	317 499	…	…
NH white females	31.9%	317 321	…	…
NH black males	46.0%	48 098	…	…
NH black females	48.3%	48 138	…	…
Hispanic males	32.4%	23 892	…	…
Hispanic females	32.5%	20 976	…	…
NH Asian or Pacific Islander	…	18 819‡	…	…
NH American Indian/Alaska Native	…	3895	…	…

Ellipses (…) indicate data not available; and NH, non-Hispanic.

*Mortality for Hispanic, American Indian or Alaska Native, and Asian and Pacific Islander people should be interpreted with caution because of inconsistencies in reporting Hispanic origin or race on the death certificate compared with censuses, surveys, and birth certificates. Studies have shown underreporting on death certificates of American Indian or Alaska Native, Asian and Pacific Islander, and Hispanic decedents, as well as undercounts of these groups in censuses.

†These percentages represent the portion of total cardiovascular disease mortality that is attributable to males vs females.

‡Includes Chinese, Filipino, Hawaiian, Japanese, and other Asian or Pacific Islander.

Sources: Prevalence: National Health and Nutrition Examination Survey 2009 to 2012, National Center for Health Statistics (NCHS) and National Heart, Lung, and Blood Institute (NHLBI). Percentages for racial/ethnic groups are age adjusted for Americans ≥20 years of age. Age-specific percentages are extrapolated to the 2012 US population estimates. Mortality: Centers for Disease Control and Prevention/NCHS, 2013 Mortality Multiple Cause-of-Death–United States. These data represent underlying cause of death only for *International Classification of Diseases, 10th Revision* codes I00 to I99 (diseases of the circulatory system). Hospital discharges: National Hospital Discharge Survey, NCHS. Data include those inpatients discharged alive, dead, or of unknown status. Cost: NHLBI. Data include estimated direct and indirect costs for 2011 to 2012 (annual average).

Table 13-2. Age-Adjusted Death Rates per 100 000 Population for CVD, CHD, and Stroke by State, 2011–2013

	CVD*			CHD†			Stroke‡		
State	Rank§	Death Rate	% Change, 2001–2003 to 2011–2013	Rank§	Death Rate	% Change, 2001–2003 to 2011–2013	Rank§	Death Rate	% Change, 2001–2003 to 2011–2013
Alabama	51	296.9	–22.5	26	100.1	–33.5	51	49.0	–28.3
Alaska	11	194.4	–27.4	7	75.7	–35.0	38	40.9	–30.4
Arizona	9	194.0	–29.0	29	101.5	–34.1	5	29.7	–37.9
Arkansas	49	281.2	–24.4	48	132.8	–29.4	52	49.1	–34.1
California	24	209.3	–32.9	31	102.9	–41.5	20	35.6	–40.6
Colorado	3	176.4	–34.0	5	72.8	–39.8	12	33.0	–38.9
Connecticut	12	195.3	–30.2	11	84.2	–42.1	2	27.9	–40.3
Delaware	30	221.4	–30.8	39	113.8	–38.2	32	38.5	–23.8
District of Columbia	44	259.5	–29.9	49	135.0	–36.9	10	32.6	–31.5
Florida	15	198.1	–32.5	27	101.0	–41.9	7	30.9	–33.5
Georgia	37	242.2	–32.6	9	82.8	–44.7	40	41.9	–37.3
Hawaii	4	183.0	–30.0	2	69.1	–33.1	18	35.2	–40.7
Idaho	19	204.3	–28.6	12	85.7	–38.1	27	37.1	–40.2
Illinois	33	227.3	–30.4	30	102.3	–41.2	29	37.7	–34.4
Indiana	40	247.8	–27.1	38	111.8	–34.3	42	42.5	–30.7
Iowa	28	220.4	–26.3	42	118.3	–31.2	15	34.3	–40.2
Kansas	27	220.2	–28.4	17	89.6	–36.9	34	39.0	–34.6
Kentucky	45	267.9	–28.5	43	118.4	–36.5	44	43.5	–31.8
Louisiana	48	275.2	–24.7	37	111.7	–36.7	46	44.5	–29.9
Maine	14	197.3	–31.2	14	87.2	–40.9	16	34.5	–36.0
Maryland	31	224.7	–30.6	35	109.2	–39.1	26	36.8	–35.9
Massachusetts	5	184.8	–32.9	10	83.0	–39.2	3	28.7	–40.6
Michigan	43	255.1	–27.1	47	130.8	–32.8	28	37.4	–34.8
Minnesota	1	167.9	–29.4	1	65.6	–38.5	13	33.3	–34.4
Mississippi	52	309.8	–26.5	44	118.6	–37.8	50	48.7	–29.1
Missouri	42	253.0	–28.6	45	123.0	–34.5	41	42.1	–30.9
Montana	20	205.2	–25.2	13	86.7	–26.8	24	36.2	–38.6
Nebraska	17	202.1	–30.1	8	77.9	–36.0	23	36.0	–35.5
Nevada	39	246.1	–26.1	23	99.3	–32.2	17	34.5	–39.5
New Hampshire	8	191.9	–35.3	18	92.2	–46.2	6	29.7	–39.4
New Jersey	29	220.9	–29.1	33	108.9	–40.1	11	32.6	–26.1
New Mexico	10	194.2	–26.4	22	98.7	–31.7	8	31.2	–31.6
New York	35	231.8	–31.0	50	135.1	–40.0	1	26.8	–28.5
North Carolina	32	225.6	–32.0	28	101.0	–38.8	43	42.8	–38.1
North Dakota	18	202.2	–29.5	21	98.6	–37.8	21	35.6	–38.2
Ohio	41	248.4	–27.9	40	116.9	–37.2	37	40.8	–30.0
Oklahoma	50	289.1	–27.8	52	149.8	–34.0	47	45.4	–32.8
Oregon	6	191.1	–32.9	4	72.5	–42.6	33	38.7	–44.0
Pennsylvania	36	234.2	–28.9	34	109.1	–38.0	31	38.1	–30.6
Puerto Rico	2	172.2	–28.8	6	72.9	–39.4	14	33.9	–28.0
Rhode Island	21	206.1	–32.2	41	117.8	–41.8	4	29.2	–36.4
South Carolina	38	244.8	–28.7	24	99.9	–36.4	49	46.6	–36.9
South Dakota	23	209.2	–26.6	36	110.0	–28.4	35	39.2	–25.8
Tennessee	46	268.4	–29.4	51	139.5	–34.2	48	45.6	–36.0
Texas	34	227.5	–32.5	32	103.1	–42.3	39	41.3	–34.5
Utah	13	196.8	–25.8	3	69.9	–32.7	30	38.0	–33.1

(*Continued*)

Table 13-2. Continued

State	CVD* Rank§	CVD* Death Rate	CVD* % Change, 2001–2003 to 2011–2013	CHD† Rank§	CHD† Death Rate	CHD† % Change, 2001–2003 to 2011–2013	Stroke‡ Rank§	Stroke‡ Death Rate	Stroke‡ % Change, 2001–2003 to 2011–2013
Vermont	16	198.3	–29.9	25	99.9	–34.7	9	32.3	–35.0
Virginia	26	214.9	–31.5	15	88.7	–39.1	36	40.3	–36.0
Washington	7	191.8	–32.8	16	88.7	–39.7	19	35.2	–46.4
West Virginia	47	270.6	–28.8	46	128.5	–37.6	45	44.4	–26.2
Wisconsin	25	213.1	–28.0	20	96.6	–34.2	25	36.4	–37.1
Wyoming	22	208.7	–26.0	19	92.3	–30.2	22	35.7	–34.4
Total United States		225.2	–30.2		105.7	–38.8		37.0	–34.7

CHD indicates coronary heart disease; and CVD, cardiovascular disease.

*CVD is defined here as *International Classification of Diseases, 10th Revision* (*ICD-10*) codes I00 to I99.

†CHD is defined here as *ICD-10* codes I20 to I25.

‡Stroke is defined here as *ICD-10* codes I60 to I69.

§Rank is lowest to highest.

Source: Centers for Disease Control and Prevention (CDC) Wide-Ranging Online Data for Epidemiologic Research (WONDER), 2001 to 2013. Data provided by personal communication with the National Heart, Lung, and Blood Institute.

Additional resources for state-level mortality data: The Agency for Healthcare Research and Quality has released state-level data for heart disease for all 50 states and the District of Columbia; the data are taken from the congressionally mandated National Healthcare Quality Report.[39] In addition, the *Women's Health and Mortality Chartbook* of the National Center for Health Statistics has state-related data for women.[40] Metropolitan/micropolitan area risk data are available for 500 such areas nationwide.[41] Behavioral Risk Factor Surveillance System data are also collected within each state.[42] The CDC has the Geographic Information Systems, which provides mortality rates down to the county level, by sex and ethnicity.[43] The 2008 *Atlas of Stroke Hospitalizations Among Medicare Beneficiaries* is a resource that provides data down to the county level, by sex and race.[44]

Table 13-3. Death Rates for Cardiovascular Diseases and All Causes in Selected Countries

Sorted Alphabetically by Country	CVD	CHD	Stroke	Total	Sorted by Descending CVD Death Rate	CVD	CHD	Stroke	Total
Men aged 35–74 y									
Australia (2011)	126.1	76.9	18.7	530.3	Belarus (2011)	1178.0	826.0	232.0	2375.9
Austria (2013)	178.0	104.3	24.4	689.5	Russian Federation (2011)	1087.0	610.2	268.2	2254.4
Belarus (2011)	1178.0	826.0	232.0	2375.9	Ukraine (2012)	1067.2	718.1	216.6	2069.3
Belgium (2012)	151.8	64.4	26.1	734.9	Bulgaria (2011)	787.3	179.3	184.3	1448.7
Bulgaria (2011)	787.3	179.3	184.3	1448.7	Romania (2012)	594.6	242.9	167.0	1427.8
Croatia (2013)	356.7	181.3	93.6	1050.8	Hungary (2013)	499.7	268.1	95.4	1378.5
Czech Republic (2013)	340.8	191.9	52.0	979.1	Croatia (2013)	356.7	181.3	93.6	1050.8
Denmark (2012)	135.8	57.3	29.1	694.9	Czech Republic (2013)	340.8	191.9	52.0	979.1
Finland (2013)	230.0	128.2	37.9	727.4	United States (2013)	234.0	128.0	27.1	810.4
France (2011)	121.2	46.4	22.6	718.4	Finland (2013)	230.0	128.2	37.9	727.4
Germany (2013)	197.9	96.2	27.4	740.3	Germany (2013)	197.9	96.2	27.4	740.3
Hungary (2013)	499.7	268.1	95.4	1378.5	United Kingdom (2011)	178.5	111.0	26.8	648.0
Israel (2012)	114.1	52.1	25.6	569.7	Austria (2013)	178.0	104.3	24.4	689.5
Italy (2012)	141.8	64.9	25.5	579.1	Taiwan (2013)	169.4	48.4	54.1	841.6
Japan (2013)	132.4	43.8	43.5	563.8	New Zealand (2011)	164.8	106.3	25.9	576.1
Korea, South (2012)	119.7	36.1	51.6	710.4	Belgium (2012)	151.8	64.4	26.1	734.9
Netherlands (2013)	127.0	47.0	23.5	573.4	Sweden (2013)	151.1	83.5	22.3	519.3
New Zealand (2011)	164.8	106.3	25.9	576.1	Italy (2012)	141.8	64.9	25.5	579.1
Norway (2013)	123.9	66.8	22.2	550.5	Portugal (2013)	141.5	52.4	48.9	764.5
Portugal (2013)	141.5	52.4	48.9	764.5	Denmark (2012)	135.8	57.3	29.1	694.9

(*Continued*)

Table 13-3. Continued

Sorted Alphabetically by Country	CVD	CHD	Stroke	Total	Sorted by Descending CVD Death Rate	CVD	CHD	Stroke	Total
Romania (2012)	594.6	242.9	167.0	1427.8	Spain (2013)	132.7	62.2	22.9	605.9
Russian Federation (2011)	1087.0	610.2	268.2	2254.4	Japan (2013)	132.4	43.8	43.5	563.8
Spain (2013)	132.7	62.2	22.9	605.9	Netherlands (2013)	127.0	47.0	23.5	573.4
Sweden (2013)	151.1	83.5	22.3	519.3	Australia (2011)	126.1	76.9	18.7	530.3
Switzerland (2012)	119.9	58.9	13.3	512.7	Norway (2013)	123.9	66.8	22.2	550.5
Taiwan (2013)	169.4	48.4	54.1	841.6	France (2011)	121.2	46.4	22.6	718.4
Ukraine (2012)	1067.2	718.1	216.6	2069.3	Switzerland (2012)	119.9	58.9	13.3	512.7
United Kingdom (2011)	178.5	111.0	26.8	648.0	Korea, South (2012)	119.7	36.1	51.6	710.4
United States (2013)	234.0	128.0	27.1	810.4	Israel (2012)	114.1	52.1	25.6	569.7
Women aged 35–74 y									
Australia (2011)	52.3	21.6	13.5	318.3	Ukraine (2012)	454.2	294.7	115.8	833.7
Austria (2013)	69.8	29.6	14.8	360.5	Russian Federation (2011)	431.5	212.5	137.8	864.4
Belarus (2011)	431.1	271.3	118.7	821.2	Belarus (2011)	431.1	271.3	118.7	821.2
Belgium (2012)	69.4	18.8	18.9	408.9	Bulgaria (2011)	345.1	56.6	95.6	648.5
Bulgaria (2011)	345.1	56.6	95.6	648.5	Romania (2012)	279.9	93.9	97.3	641.8
Croatia (2013)	141.9	60.3	49.6	465.9	Hungary (2013)	205.2	97.5	45.5	649.2
Czech Republic (2013)	138.2	63.1	28.6	472.9	Croatia (2013)	141.9	60.3	49.6	465.9
Denmark (2012)	58.9	18.9	17.5	451.1	Czech Republic (2013)	138.2	63.1	28.6	472.9
Finland (2013)	68.6	27.5	19.4	345.3	United States (2013)	114.5	48.8	19.7	513.0
France (2011)	42.9	10.0	12.3	330.7	Germany (2013)	81.4	28.4	16.6	398.0
Germany (2013)	81.4	28.4	16.6	398.0	New Zealand (2011)	77.9	34.3	22.3	400.6
Hungary (2013)	205.2	97.5	45.5	649.2	United Kingdom (2011)	75.8	33.0	19.7	419.3
Israel (2012)	44.5	14.6	12.5	334.9	Austria (2013)	69.8	29.6	14.8	360.5
Italy (2012)	59.4	18.2	16.4	313.8	Belgium (2012)	69.4	18.8	18.9	408.9
Japan (2013)	48.4	11.5	18.7	257.3	Finland (2013)	68.6	27.5	19.4	345.3
Korea, South (2012)	52.9	11.5	26.4	278.8	Taiwan (2013)	65.6	15.6	21.9	394.4
Netherlands (2013)	59.5	15.6	16.4	390.0	Sweden (2013)	65.1	25.4	16.0	344.6
New Zealand (2011)	77.9	34.3	22.3	400.6	Portugal (2013)	60.0	14.4	24.7	329.0
Norway (2013)	49.7	17.7	15.1	352.7	Netherlands (2013)	59.5	15.6	16.4	390.0
Portugal (2013)	60.0	14.4	24.7	329.0	Italy (2012)	59.4	18.2	16.4	313.8
Romania (2012)	279.9	93.9	97.3	641.8	Denmark (2012)	58.9	18.9	17.5	451.1
Russian Federation (2011)	431.5	212.5	137.8	864.4	Korea, South (2012)	52.9	11.5	26.4	278.8
Spain (2013)	47.3	13.9	13.0	270.8	Australia (2011)	52.3	21.6	13.5	318.3
Sweden (2013)	65.1	25.4	16.0	344.6	Norway (2013)	49.7	17.7	15.1	352.7
Switzerland (2012)	45.5	14.2	10.3	300.6	Japan (2013)	48.4	11.5	18.7	257.3
Taiwan (2013)	65.6	15.6	21.9	394.4	Spain (2013)	47.3	13.9	13.0	270.8
Ukraine (2012)	454.2	294.7	115.8	833.7	Switzerland (2012)	45.5	14.2	10.3	300.6
United Kingdom (2011)	75.8	33.0	19.7	419.3	Israel (2012)	44.5	14.6	12.5	334.9
United States (2013)	114.5	48.8	19.7	513.0	France (2011)	42.9	10.0	12.3	330.7

Rates are for the most recent year available (shown in parentheses); most current data available as of June 2015. Rates are per 100 000 people, adjusted to the European Standard population. *International Classification of Diseases, 10th Revision* codes used were I00 to I99 for cardiovascular disease, I20 to I25 for coronary heart disease, and I60 to I69 for stroke. CHD indicates coronary heart disease; and CVD, cardiovascular disease.

Sources: The World Health Organization, National Center for Health Statistics, and National Heart, Lung, and Blood Institute.

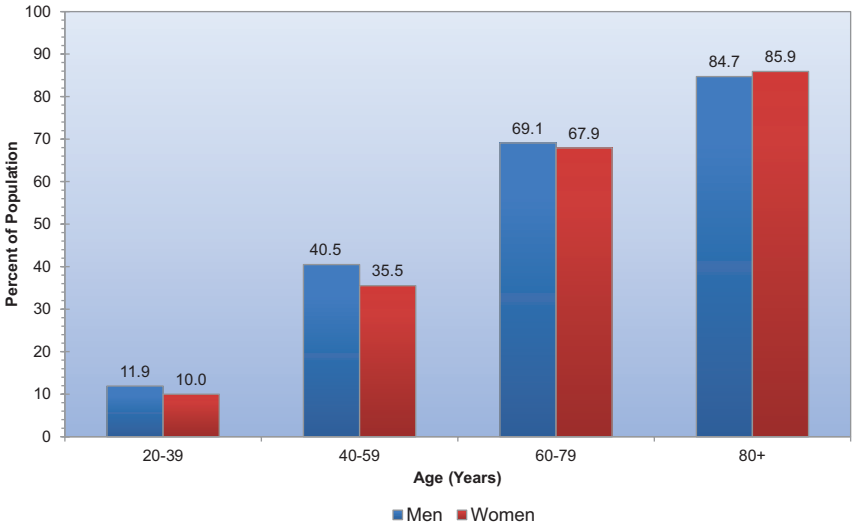


Chart 13-1. Prevalence of cardiovascular disease in adults ≥20 years of age by age and sex (National Health and Nutrition Examination Survey: 2009–2012). These data include coronary heart disease, heart failure, stroke, and hypertension. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

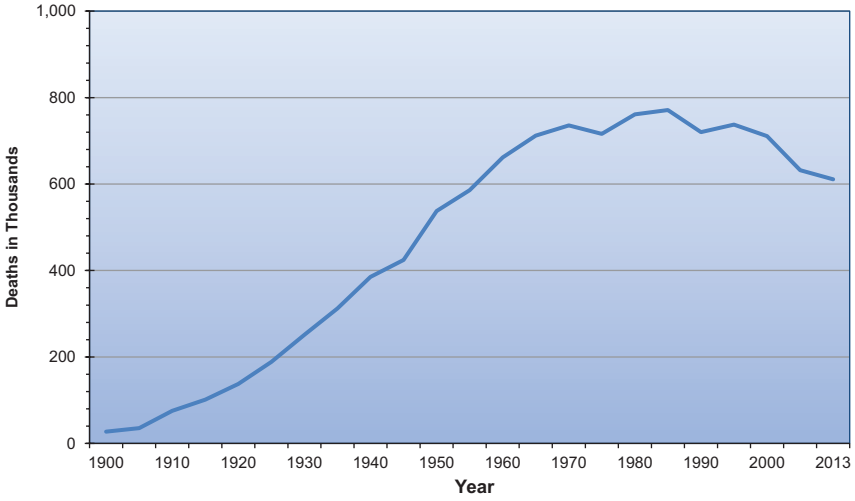


Chart 13-2. Deaths attributable to diseases of the heart (United States: 1900–2013). See Glossary (Chapter 27) for an explanation of "diseases of the heart." In the years 1900 to 1920, the *International Classification of Diseases* codes were 77 to 80; for 1925, 87 to 90; for 1930 to 1945, 90 to 95; for 1950 to 1960, 402 to 404 and 410 to 443; for 1965, 402 to 404 and 410 to 443; for 1970 to 1975, 390 to 398 and 404 to 429; for 1980 to 1995, 390 to 398, 402, and 404 to 429; and for 2000 to 2013, I00 to I09, I11, I13, and I20 to I51. Before 1933, data are for a death registration area and not the entire United States. In 1900, only 10 states were included in the death registration area, and this increased over the years, so part of the increase in numbers of deaths is attributable to an increase in the number of states. Source: National Center for Health Statistics.

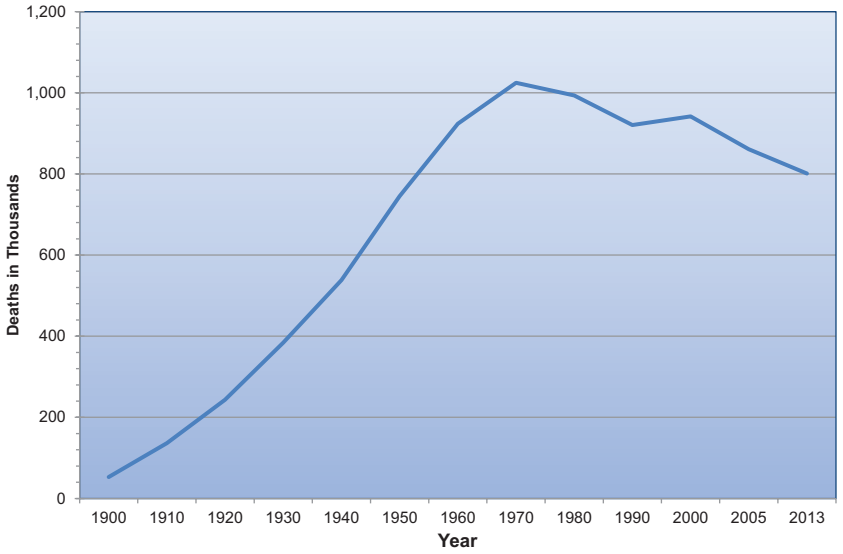


Chart 13-3. Deaths attributable to cardiovascular disease (United States: 1900–2013). Cardiovascular disease (*International Classification of Diseases, 10th Revision* codes I00–I99) does not include congenital heart disease. Before 1933, data are for a death registration area and not the entire United States. Source: National Center for Health Statistics.

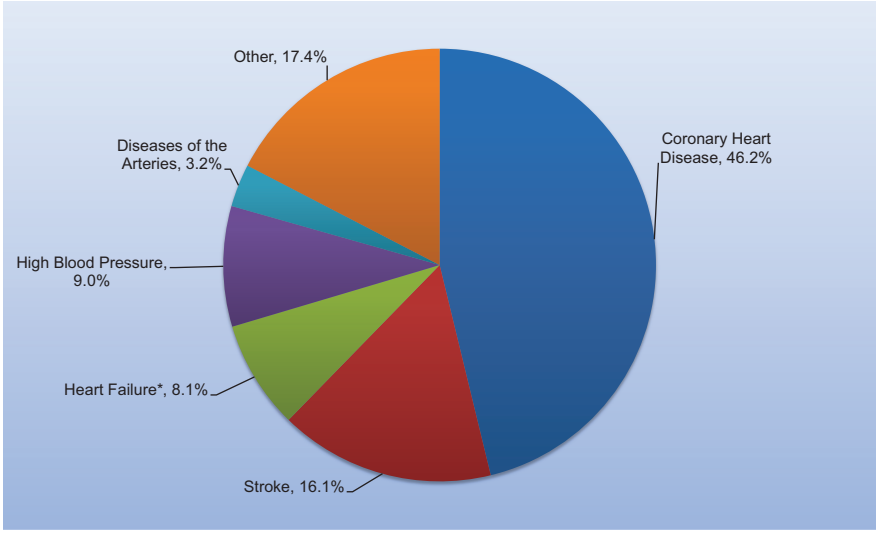


Chart 13-4. Percentage breakdown of deaths attributable to cardiovascular disease (United States: 2013). Total may not add to 100 because of rounding. Coronary heart disease includes *International Classification of Diseases, 10th Revision* (*ICD-10*) codes I20 to I25; stroke, I60 to I69; heart failure, I50; high blood pressure, I10 to I15; diseases of the arteries, I70 to I78; and other, all remaining *ICD-I0* I categories. *Not a true underlying cause. With any-mention deaths, heart failure accounts for 36% of cardiovascular disease deaths. Source: National Heart, Lung, and Blood Institute from National Center for Health Statistics reports and data sets.

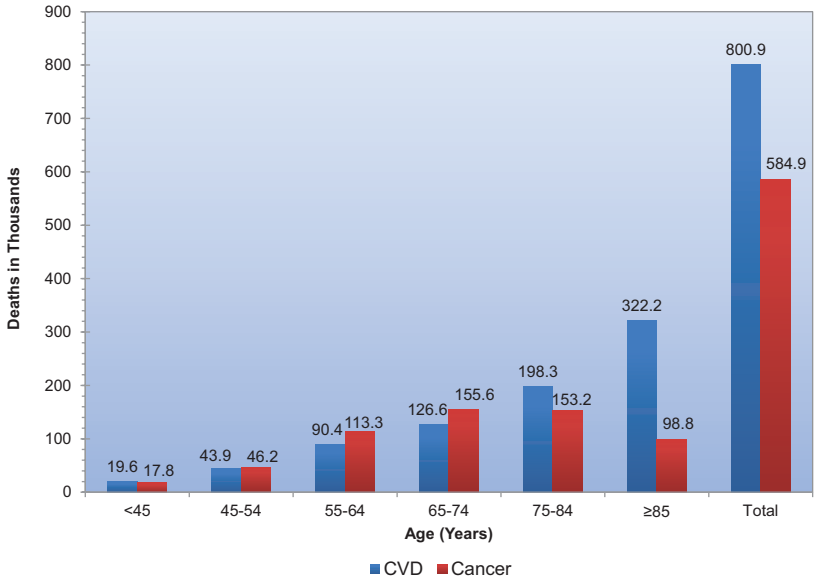


Chart 13-5. Cardiovascular disease (CVD) deaths vs cancer deaths by age (United States: 2013). CVD includes *International Classification of Diseases, 10th Revision* codes I00 to I99; and cancer, C00 to C97. Source: National Center for Health Statistics.

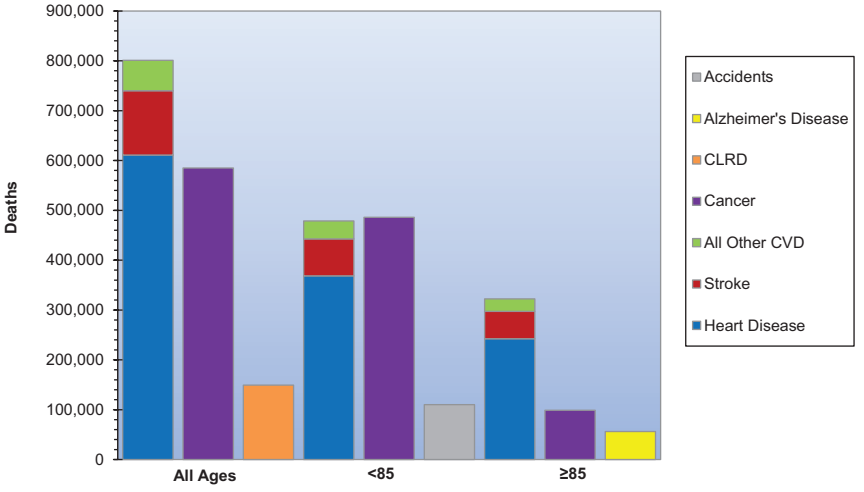


Chart 13-6. Cardiovascular disease (CVD) and other major causes of death: total, <85 years of age, and ≥85 years of age. Deaths among both sexes, United States, 2013. Heart disease includes *International Classification of Diseases, 10th Revision* codes I00 to I09, I11, I13, and I20 to I51; stroke, I60 to I69; all other CVD, I10, I12, I15, and I70 to I99; cancer, C00 to C97; chronic lower respiratory disease (CLRD), J40 to J47; Alzheimer disease, G30; and accidents, V01 to X59 and Y85 and Y86. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

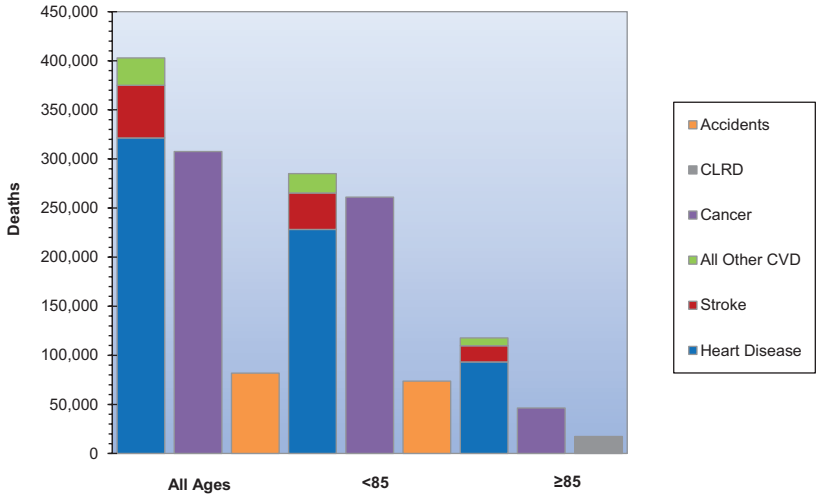


Chart 13-7. Cardiovascular disease (CVD) and other major causes of death in males: total, <85 years of age, and ≥85 years of age. Deaths among males, United States, 2013. Heart disease includes *International Classification of Diseases, 10th Revision* codes I00 to I09, I11, I13, and I20 to I51; stroke, I60 to I69; all other CVD, I10, I12, I15, and I70 to I99; cancer, C00 to C97; chronic lower respiratory disease (CLRD), J40 to J47; and accidents, V01 to X59 and Y85 and Y86. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

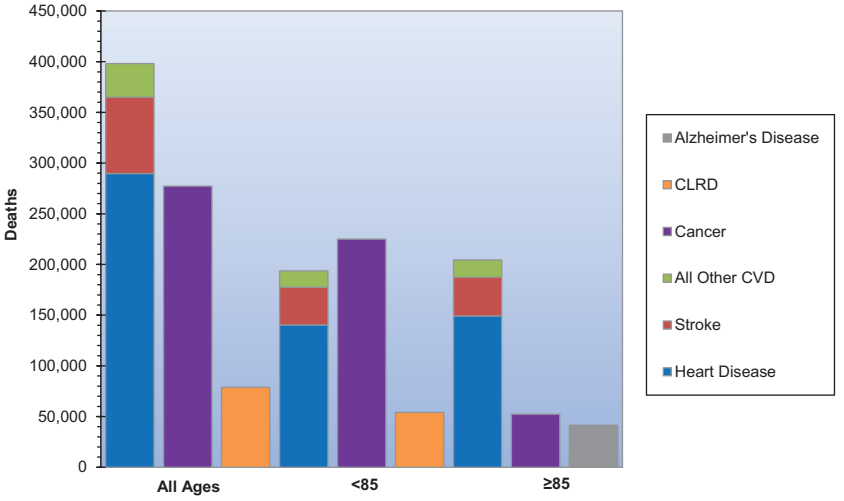


Chart 13-8. Cardiovascular disease (CVD) and other major causes of death in females: total, <85 years of age, and ≥85 years of age. Deaths among females, United States, 2013. Heart disease includes *International Classification of Diseases, 10th Revision* codes I00 to I09, I11, I13, and I20 to I51; stroke, I60 to I69; all other CVD, I10, I12, I15, and I70 to I99; cancer, C00 to C97; chronic lower respiratory disease (CLRD), J40 to J47; and Alzheimer disease, G30. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

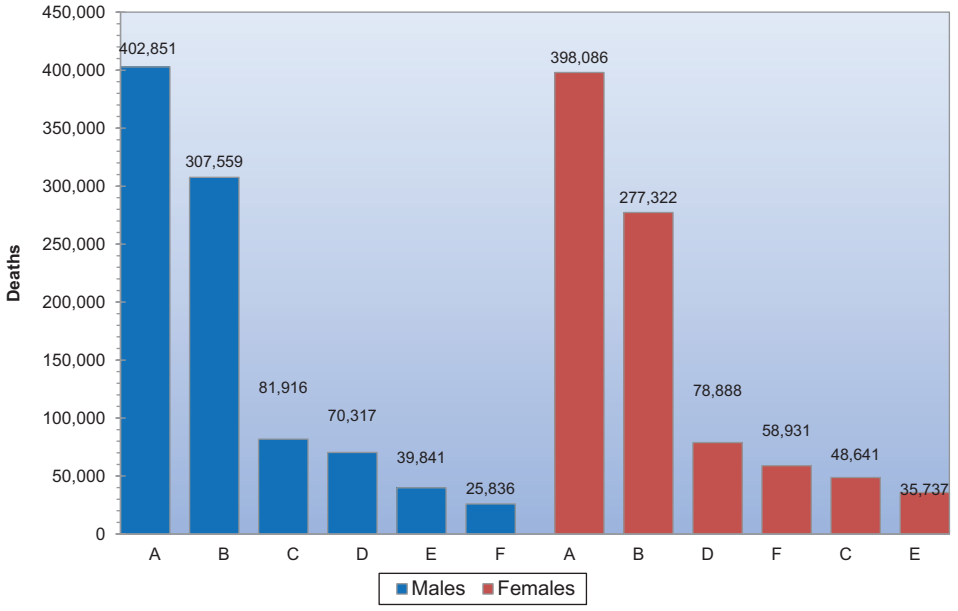


Chart 13-9. Cardiovascular disease and other major causes of death for all males and females (United States: 2013). A indicates cardiovascular disease (*International Classification of Diseases, 10th Revision* codes I00–I99); B, cancer (C00–C97); C, accidents (V01–X59 and Y85–Y86); D, chronic lower respiratory disease (J40–J47); E, diabetes mellitus (E10–E14); and F, Alzheimer disease (G30). Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

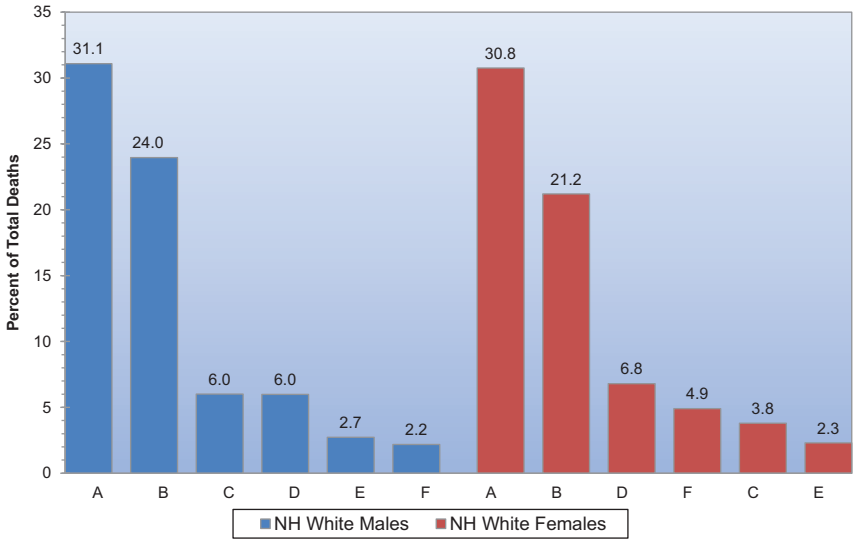


Chart 13-10. Cardiovascular disease and other major causes of death for non-Hispanic (NH) white males and females (United States: 2013). A indicates cardiovascular disease (*International Classification of Diseases, 10th Revision* codes I00–I99); B, cancer (C00–C97); C, accidents (V01–X59 andY85–Y86); D, chronic lower respiratory disease (J40–J47); E, diabetes mellitus (E10–E14); and F, Alzheimer disease (G30). Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

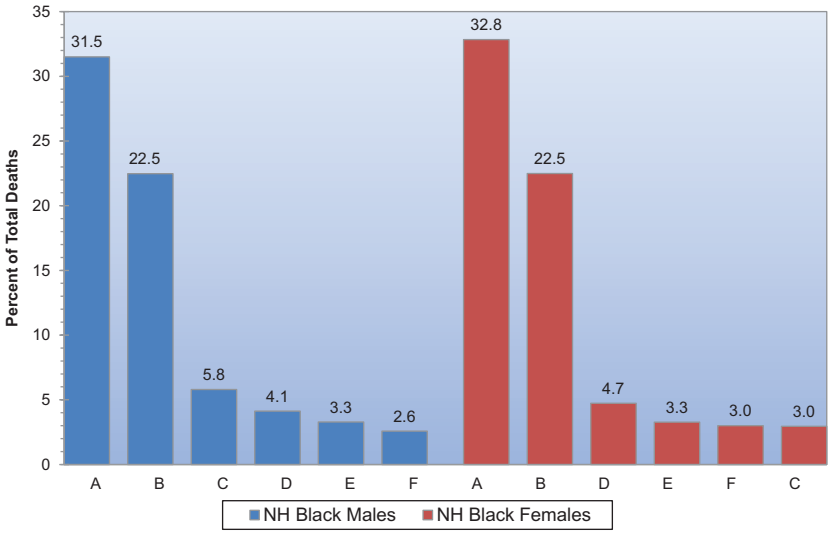


Chart 13-11. Cardiovascular disease and other major causes of death for non-Hispanic (NH) black males and females (United States: 2013). A indicates cardiovascular disease (*International Classification of Diseases, 10th Revision* codes I00–I99); B, cancer (C00–C97); C, accidents (V01–X59 and Y85–Y86); D, diabetes mellitus (E10–E14); E, chronic lower respiratory disease (J40–J47); and F, nephritis (N00–N07, N17–N19, and N25–N27). Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

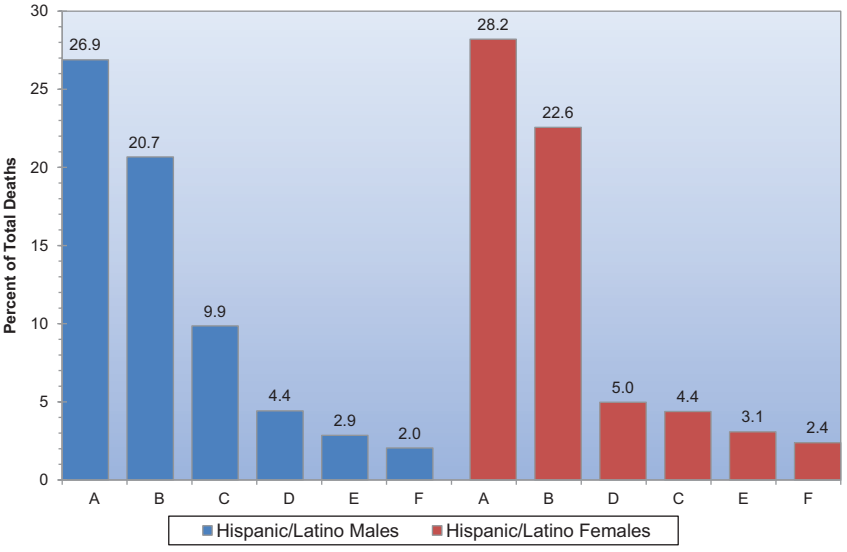


Chart 13-12. Cardiovascular disease and other major causes of death for Hispanic or Latino males and females (United States: 2013). A indicates cardiovascular disease (*International Classification of Diseases, 10th Revision* codes I00–I99); B, cancer (C00–C97); C, accidents (V01–X59 and Y85–Y86); D, diabetes mellitus (E10–E14); E, chronic lower respiratory disease (J40–J47); and F, Alzheimer disease (G30). Number of deaths shown may be lower than actual because of underreporting in this population. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

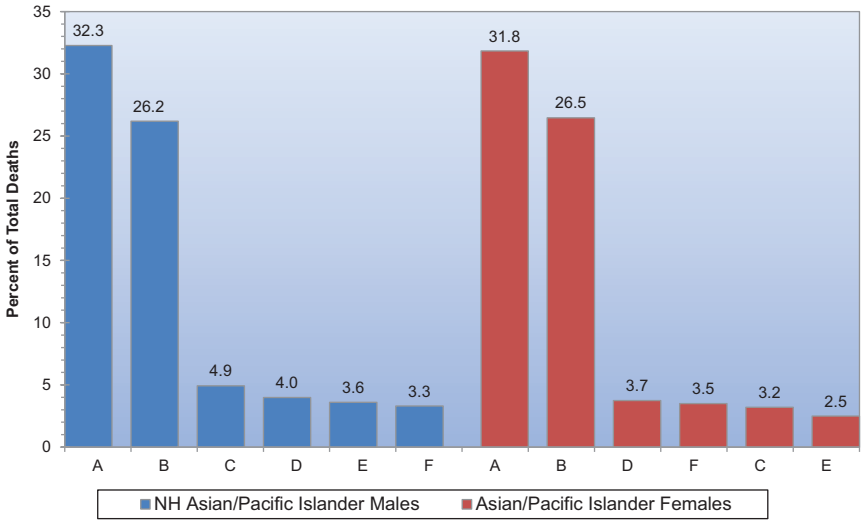


Chart 13-13. Cardiovascular disease and other major causes of death for non-Hispanic (NH) Asian or Pacific Islander males and females (United States: 2013). "Asian or Pacific Islander" is a heterogeneous category that includes people at high cardiovascular disease risk (eg, South Asian) and people at low cardiovascular disease risk (eg, Japanese). More specific data on these groups are not available. A indicates cardiovascular disease (*International Classification of Diseases, 10th Revision* codes I00–I99); B, cancer (C00–C97); C, accidents (V01–X59 and Y85–Y86); D, diabetes mellitus (E10–E14); E, chronic lower respiratory disease (J40–J47); and F, influenza and pneumonia (J09–J18). Number of deaths shown may be lower than actual because of underreporting in this population. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

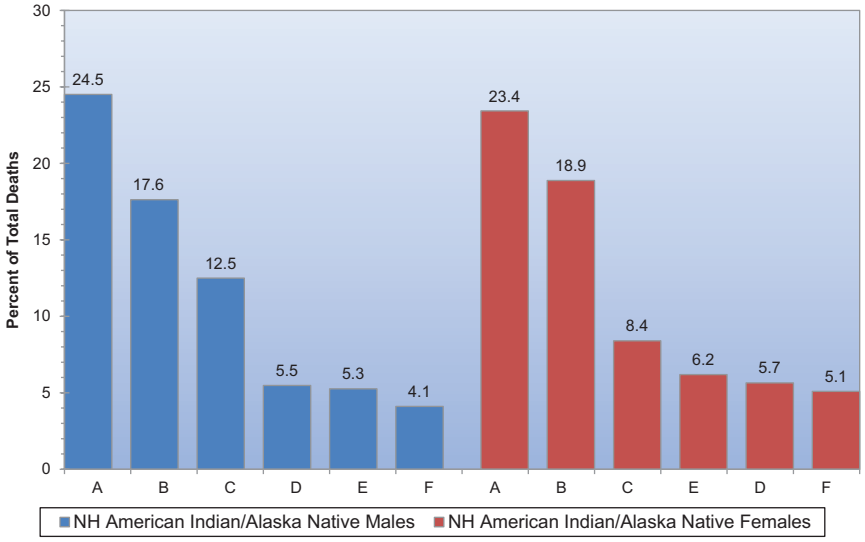


Chart 13-14. Cardiovascular disease and other major causes of death for non-Hispanic (NH) American Indian or Alaska Native males and females (United States: 2013). A indicates cardiovascular disease (*International Classification of Diseases, 10th Revision* codes I00–I99); B, cancer (C00–C97); C, accidents (V01–X59 and Y85–Y86); D, diabetes mellitus (E10–E14); E, chronic liver disease (K70 and K73–K74); and F, chronic lower respiratory disease (J40–J47). Number of deaths shown may be lower than actual because of underreporting in this population. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

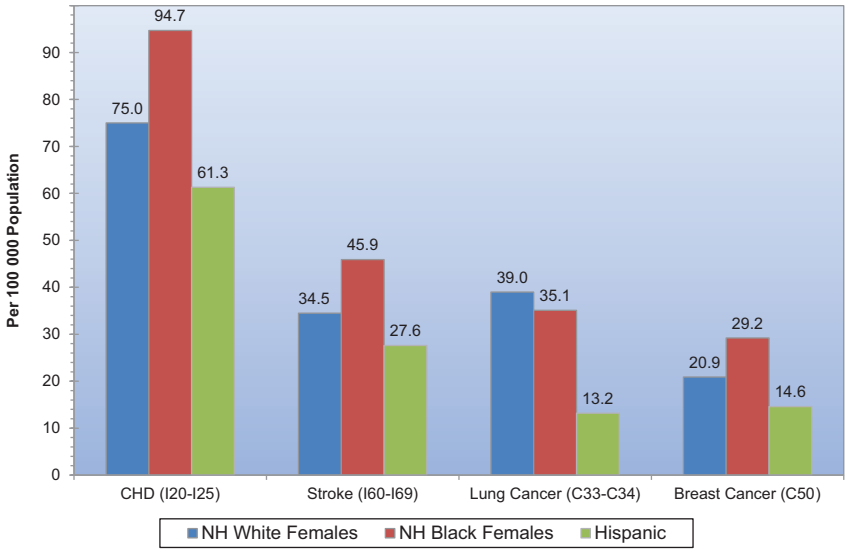


Chart 13-15. Age-adjusted death rates for coronary heart disease (CHD), stroke, and lung and breast cancer for white and black females (United States: 2013).CHD includes *International Classification of Diseases, 10th Revision* codes I20 to I25; stroke, I60 to I69; lung cancer, C33 to C34; and breast cancer, C50. NH indicates non-Hispanic. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

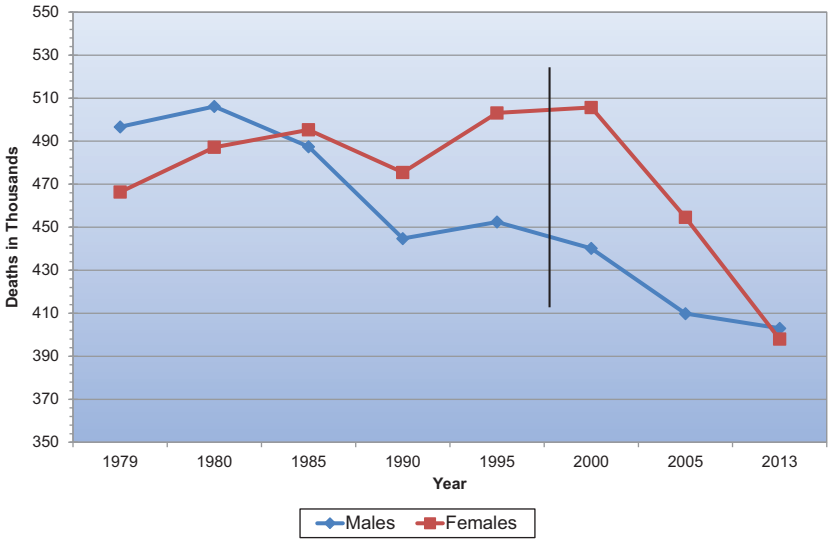


Chart 13-16. Cardiovascular disease mortality trends for males and females (United States: 1979–2013). Cardiovascular disease excludes congenital cardiovascular defects (*International Classification of Diseases, 10th Revision* [*ICD-10*] codes I00–I99). The overall comparability for cardiovascular disease between the *International Classification of Diseases, 9th Revision* (1979–1998) and *ICD-10* (1999–2013) is 0.9962. No comparability ratios were applied. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

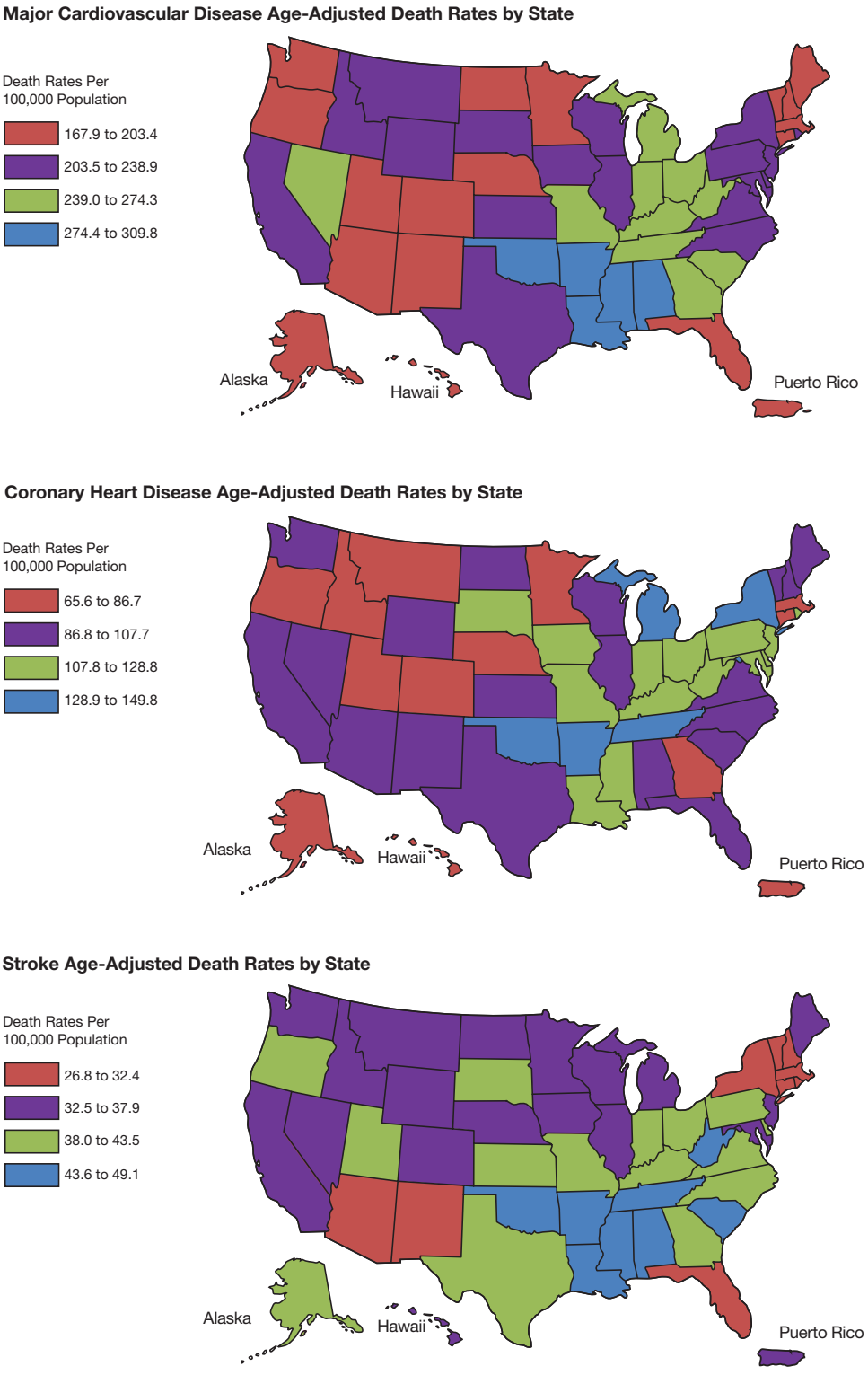
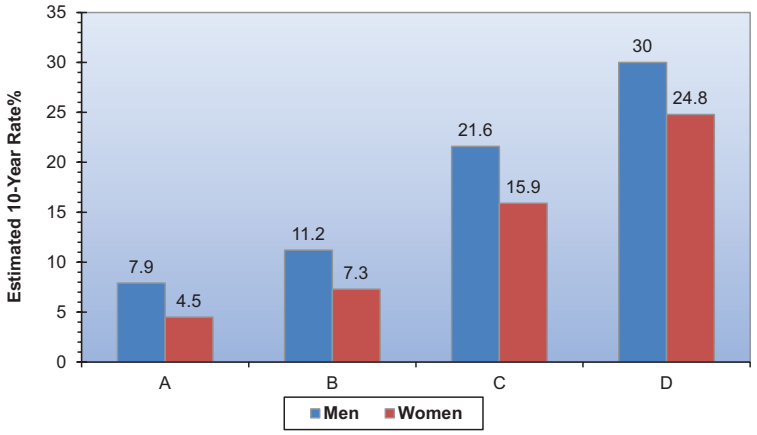


Chart 13-17. US maps corresponding to state death rates (including the District of Columbia), 2013.



	A	B	C	D
Age	50-54	50-54	50-54	50-54
HDL Cholesterol, mg/dL	45-49	45-49	35-44	35-44
Total Cholesterol, mg/dL	160-199	200-239	200-239	200-239
Systolic BP mm/Hg, no treatment	120-129	130-139	130-139	130-139
Smoker	No	No	No	Yes
Diabetes	No	No	Yes	Yes

Chart 13-18. Estimated average 10-year cardiovascular disease risk in adults 50 to 54 years of age according to levels of various risk factors (Framingham Heart Study). BP indicates blood pressure; and HDL, high-density lipoprotein. Data derived from D'Agostino et al[46] with permission. Copyright © 2008, American Heart Association.

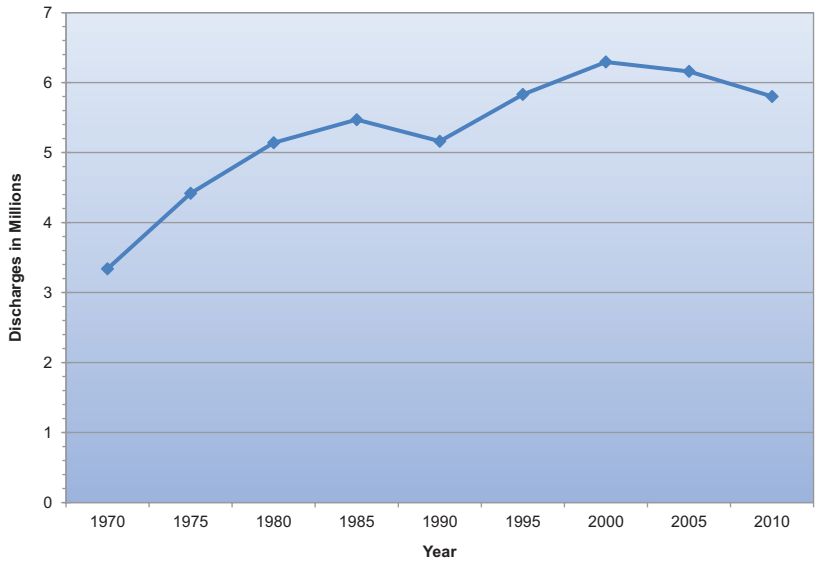


Chart 13-19. Hospital discharges for cardiovascular disease (United States: 1970–2010). Hospital discharges include people discharged alive, dead, and "status unknown." Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

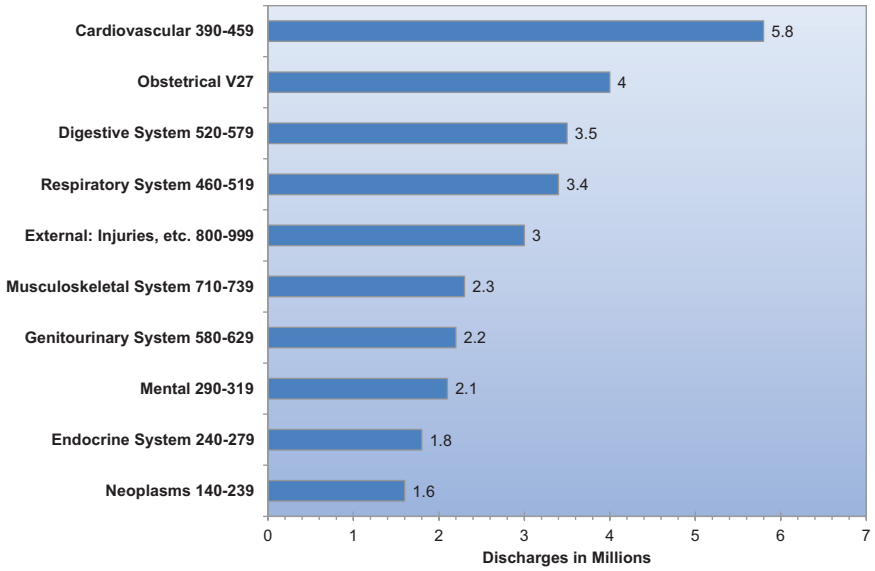


Chart 13-20. Hospital discharges (*International Classification of Diseases, 9th Revision*) for the 10 leading diagnostic groups (United States: 2010). Source: National Hospital Discharge Survey/National Center for Health Statistics and National Heart, Lung, and Blood Institute.

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14. Stroke (Cerebrovascular Disease)

ICD-9 430 to 438; ICD-10 I60 to I69. See Tables 14-1 and 14-2 and Charts 14-1 through 14-12.

Stroke Prevalence

(See Table 14-1 and Chart 14-1.)

- An estimated 6.6 million Americans ≥20 years of age have had a stroke (extrapolated to 2012 by use of NHANES 2009–2012 data). Overall stroke prevalence during this period is an estimated 2.6% (NHANES, NHLBI).
- According to data from the 2013 BRFSS (CDC), 2.7% of men and 2.7% of women ≥18 years of age had a history of stroke; 2.5% of non-Hispanic whites, 4.0% of non-Hispanic blacks, 1.3% of Asian/Pacific Islanders, 2.3% of Hispanics (of any race), 4.6% of American Indian/Alaska Natives, and 4.6% of other races or multiracial people had a history of stroke.[1]
- Over the time period 2006 to 2010, data from BRFSS show that the overall self-reported stroke prevalence did not change. Older adults, blacks, people with lower levels

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Abbreviations Used in Chapter 14

ACCORD	Action to Control Cardiovascular Risk in Diabetes
AF	atrial fibrillation
AHA	American Heart Association
AHI	apnea-hypopnea index
ARIC	Atherosclerosis Risk in Communities study
AHRQ	Agency for Healthcare Research and Quality
BASIC	Brain Attack Surveillance in Corpus Christi
BNP	B-type natriuretic peptide
BP	blood pressure
BRFSS	Behavioral Risk Factor Surveillance System
CDC	Centers for Disease Control and Prevention
CHD	coronary heart disease
CHF	congestive heart failure
CHS	Cardiovascular Health Study
CI	confidence interval
CLRD	chronic lower respiratory disease
CREST	Carotid Revascularization Endarterectomy Versus Stenting Trial
CT	computed tomography
CVD	cardiovascular disease
DALY	disability-adjusted life-year
DM	diabetes mellitus
ED	emergency department
eGFR	estimated glomerular filtration rate
EPIC	European Prospective Investigation Into Cancer and Nutrition
ESCAPE	Endovascular Treatment for Small Core and Anterior Circulation Proximal Occlusion With Emphasis on Minimizing CT to Recanalization Times
EXTEND-IA	Extending the Time for Thrombolysis in Emergency Neurological Deficits–Intra-Arterial
FHS	Framingham Heart Study
FRS	Framingham Risk Score
FUTURE	Follow-up of TIA and Stroke Patients and Unelucidated Risk Factor Evaluation
GCNKSS	Greater Cincinnati/Northern Kentucky Stroke Study
GFR	glomerular filtration rate
GWTG	Get With The Guidelines
HBP	high blood pressure
HCUP	Healthcare Cost and Utilization Project
HD	heart disease
HDL-C	high-density lipoprotein cholesterol
HF	heart failure
HR	hazard ratio
ICD-9	*International Classification of Diseases, 9th Revision*
ICD-10	*International Classification of Diseases, 10th Revision*
ICH	intracerebral hemorrhage
IPSYS	Italian Project on Stroke in Young Adults
LDLC	low-density lipoprotein cholesterol
MEPS	Medical Expenditure Panel Survey
MESA	Multi-Ethnic Study of Atherosclerosis
MI	myocardial infarction
NAMCS	National Ambulatory Medical Care Survey
NCHS	National Center for Health Statistics
NH	non-Hispanic
NHAMCS	National Hospital Ambulatory Medical Care Survey
NHANES	National Health and Nutrition Examination Survey
NHDS	National Hospital Discharge Survey
NHIS	National Health Interview Survey
NHLBI	National Heart, Lung, and Blood Institute
NINDS	National Institutes of Neurological Disorders and Stroke
NOMAS	Northern Manhattan Study
ONTARGET	Ongoing Telmisartan Alone and in Combination With Ramipril Global Endpoint Trial
OR	odds ratio
PA	physical activity
PAR	population attributable risk
PREVEND	Prevention of Renal and Vascular End-Stage Disease
RCT	randomized controlled trial
REGARDS	Reasons for Geographic and Racial Differences in Stroke
REVASCAT	Revascularization With Solitaire FR Device Versus Best Medical Therapy in the Treatment of Acute Stroke Due to Anterior Circulation Large Vessel Occlusion Presenting Within Eight Hours of Symptom Onset
RR	relative risk
SAH	subarachnoid hemorrhage
SBP	systolic blood pressure
SHS	Strong Heart Study
SPS3	Secondary Prevention of Small Subcortical Strokes
STOP	Stroke Prevention Trial in Sickle Cell Anemia
SWIFT PRIME	Solitaire with the Intention for Thrombectomy as Primary Endovascular Treatment
TC	total cholesterol
TIA	transient ischemic attack
tPA	tissue-type plasminogen activator

of education, and people living in the southeastern United States had higher stroke prevalence.[2]

- The prevalence of silent cerebral infarction is estimated to range from 6% to 28%, with higher prevalence with increasing age.[3–5] The prevalence estimates also vary depending on the population studied (eg, ethnicity, sex, risk factor profile), definition of silent cerebral infarction, and imaging technique. It has been estimated that 13 million people had prevalent silent stroke in the 1998 US population.[6,7]
- The prevalence of stroke-related symptoms was found to be relatively high in a general population free of a prior diagnosis of stroke or TIA. On the basis of data from 18 462 participants enrolled in a national cohort study, 17.8% of the population >45 years of age reported at least 1 symptom. Stroke symptoms were more likely among blacks than whites, among those with lower income and lower educational attainment, and among those with fair to poor perceived health status. Symptoms also were more likely in participants with higher Framingham stroke risk score (REGARDS, NINDS).[8]
- Projections show that by 2030, an additional 3.4 million people aged ≥18 years will have had a stroke, a 20.5% increase in prevalence from 2012. The highest increase (29%) is projected to be in Hispanic men.[9]
- With the increase in the aging population, prevalence of stroke survivors is projected to increase, especially among elderly women.[10]

Stroke Incidence

(See Table 14-1 and Charts 14-2 through 14-5.)

- Each year, ≈795 000 people experience a new or recurrent stroke. Approximately 610 000 of these are first attacks, and 185 000 are recurrent attacks (GCNKSS, NINDS, and NHLBI; GCNKSS and NINDS data for 1999 provided July 9, 2008; estimates compiled by NHLBI).
- Of all strokes, 87% are ischemic and 10% are ICH strokes, whereas 3% are SAH strokes (GCNKSS, NINDS, 1999).
- On average, every 40 seconds, someone in the United States has a stroke (AHA computation based on the latest available data).
- Temporal trend data from the BASIC Project for the time period 2000 through 2010 demonstrated that ischemic stroke rates declined significantly in people aged ≥60 years but remained largely unchanged over time in those aged 45 to 59 years. Rates of decline did not differ significantly for non-Hispanic whites and Mexican Americans in any age group. Therefore, ethnic disparities in stroke rates in the 45- to 59-year-old and 60- to 74-year-old age groups persist.[11]
- Analysis of data from the FHS suggests that stroke incidence is declining over time in this largely white cohort. Data from 1950 to 1977, 1978 to 1989, and 1990 to 2004 showed that the age-adjusted incidence of first stroke per 1000 person-years in each of the 3 periods was 7.6, 6.2, and 5.3 in men and 6.2, 5.8, and 5.1 in women, respectively. Lifetime risk for incident stroke at 65 years of age decreased significantly in the latest data period compared with the first, from 19.5% to 14.5% in men and from 18.0% to 16.1% in women.[12]
- In a similar fashion, data from a 20% sample of hospitalized Medicare beneficiaries showed that the rate of first stroke among patients aged >65 years decreased by ≈40% over the past 2 decades (1988–2008), a decline driven primarily by marked reductions in the incidence of ischemic stroke. The decline in stroke rates occurred over a period of significant uptake in the use of medications that attenuate stroke risk: Statin use in the general population increased from 4% in 1992 to 41% in 2008, and antihypertensive drug use increased from 53% in 1992 to 74% in 2008.[13]
- Regarding trends in incidence stratified by race, the most recent GCNKSS data show that compared with the 1990s, when incidence rates of stroke were stable, stroke incidence in 2005 was decreased for whites. A similar decline was not seen in blacks. These changes for whites were driven by a decline in ischemic strokes. There were no changes in incidence of ischemic stroke for blacks or of hemorrhagic strokes in blacks or whites.[14]
- In contrast, in the multicenter ARIC study of black and white adults, stroke incidence and mortality rates decreased from 1987 to 2011. The decreases varied across age groups but were similar across sex and race.[15]
- Data from the BASIC Project showed that the age-, sex-, and ethnicity-adjusted incidence of ICH decreased from 2000 to 2010 (from an annual incidence rate of 5.21/10 000 [95% CI, 4.36–6.24] to 4.30/10 000 [95% CI, 3.21–5.76).[16]
- Each year, ≈55 000 more women than men have a stroke (GCNKSS, NINDS).[14]
- Women have a higher lifetime risk of stroke than men. In the FHS, lifetime risk of stroke among those 55 to75 years of age was 1 in 5 for women (20%–21%) and ≈1 in 6 for men (14%–17%).[17]
- Age-specific incidence rates are substantially lower in women than men in younger and middle-age groups, but these differences narrow so that in the oldest age groups, incidence rates in women are approximately equal to or even higher than in men.[10,18–22]
- In the national REGARDS cohort, in 27 744 participants followed up for 4.4 years (2003–2010), the overall age- and sex-adjusted black/white incidence rate ratio was 1.51, but for ages 45 to 54 years, it was 4.02, whereas for those ≥85 years of age, it was 0.86.[23] Similar trends for decreasing black/white incidence rate ratio with age were seen in the GCNKSS.[24]
- The BASIC Project (NINDS) demonstrated an increased incidence of stroke among Mexican Americans compared with non-Hispanic whites in a community in southeast Texas. The crude 3-year cumulative incidence (2000–2002) was 16.8 per 1000 in Mexican Americans and 13.6 per 1000 in non-Hispanic whites. Specifically, Mexican Americans had a higher cumulative incidence of ischemic stroke at younger ages (45–59 years of age: RR, 2.04; 95% CI, 1.55–2.69; 60–74 years of age: RR, 1.58; 95% CI, 1.31–1.91) but not at older ages (≥75 years of age: RR, 1.12; 95% CI, 0.94–1.32). Mexican Americans also had a higher incidence of ICH and SAH than non-Hispanic whites, after adjustment for age.[25]
- The age-adjusted incidence of first ischemic stroke per 1000 was 0.88 in whites, 1.91 in blacks, and 1.49 in Hispanics according to data from NOMAS (NINDS) for 1993 to 1997. Among blacks, compared with whites, the relative rate of intracranial atherosclerotic stroke was 5.85; of

extracranial atherosclerotic stroke, 3.18; of lacunar stroke, 3.09; and of cardioembolic stroke, 1.58. Among Hispanics (primarily Cuban and Puerto Rican), compared with whites, the relative rate of intracranial atherosclerotic stroke was 5.00; of extracranial atherosclerotic stroke, 1.71; of lacunar stroke, 2.32; and of cardioembolic stroke, 1.42.[26]

- Among 4507 American Indian participants without a prior stroke in the SHS in 1989 to 1992, the age- and sex-adjusted incidence of stroke through 2004 was 6.79 per 100 person-years, with 86% of incident strokes being ischemic.[27]
- In the REGARDS study, the increased risk of ICH with age differed between blacks and whites: There was a 2.25-fold (95% CI, 1.63–3.12) increase per decade in whites but no age association with ICH risk in blacks (HR, 1.09; 95% CI, 0.70–1.68).[28]

TIA: Prevalence, Incidence, and Prognosis

- In a nationwide survey of US adults, the estimated prevalence of self-reported physician-diagnosed TIA increased with age and was 2.3% overall, which translates to ≈5 million people. The true prevalence of TIA is greater, because many patients who experience neurological symptoms consistent with a TIA fail to report it to their healthcare provider.[29]
- In the GCNKSS, according to data from 1993 and 1994, the age-, sex-, and race-adjusted incidence rate for TIA was 0.83 per 10 000.[30] The age- and sex-adjusted incidence rate for TIA in Rochester, MN, was estimated at 0.68 per 1000 for the years 1985 through 1989.[31] In a more recent Italian community-based registry conducted in 2007 to 2009, the crude TIA incidence rate was 0.52 per 1000.[32]
- Incidence of TIA increases with age and varies by sex and race/ethnicity. Men, blacks, and Mexican Americans have higher rates of TIA than their female and non-Hispanic white counterparts.[25,30,32]
- Approximately 15% of all strokes are heralded by a TIA.[33]
- TIAs confer a substantial short-term risk of stroke, hospitalization for CVD events, and death. Of 1707 TIA patients evaluated in the ED of Kaiser Permanente Northern California, 180 (11%) experienced a stroke within 90 days, and 91 (5%) had a stroke within 2 days. Predictors of stroke included age >60 years, DM, focal symptoms of weakness or speech impairment, and symptoms that lasted >10 minutes.[34]
- Meta-analyses of cohorts of patients with TIA have shown the short-term risk of stroke after TIA to be ≈3% to 10% at 2 days and 9% to 17% at 90 days.[35,36]
- Individuals who have a TIA and survive the initial high-risk period have a 10-year stroke risk of roughly 19% and a combined 10-year stroke, MI, or vascular death risk of 43% (4% per year).[37]
- In the GCNKSS, the 1-year mortality rate after a TIA was 12%.[30]
- In the population-based Oxford Vascular Study, among patients with TIA, disability levels increased from 14% (modified Rankin scale >2) before the TIA to 23% at 5 years after the TIA (P=0.002). In this same study, the 5-year risk of institutionalization after TIA was 11%.[38]
- In a meta-analysis of 47 studies,[39] it was estimated that approximately one third of TIA patients have an acute lesion present on diffusion-weighted magnetic resonance imaging and thus would be classified as having had a stroke under a tissue-based case definition[40,41]; however, substantial between-study heterogeneity was noted.

Recurrent Stroke

- In a cohort of 10 399 patients discharged with a primary diagnosis of stroke in the state of South Carolina in 2002, recurrent stroke rates were 1.8% at 1 month, 5% at 6 months, 8% at 1 year, and 18.1% at 4 years.[42]
- Annual recurrent stroke rates in control arms of stroke prevention trials fell from 8.71% in trials launched in the 1960s to 6.10% in the 1970s, 5.41% in the 1980s, 4.04% in the 1990s, and 4.98% in the 2000s. If one assumes a continued linear decline, the annual recurrent stroke rate in trial control arms in the coming decade is projected to be 2.25%.[43]
- From 1994 to 2002, 1-year recurrent ischemic stroke rates declined by almost 5% among elderly Medicare beneficiaries, but declines were heterogeneous across geographic regions of the United States.[44]
- Among 600 Scandinavian stroke patients followed up for 2 years, 55 (9.2%) had had a recurrent stroke, 15 (2.5%) had a TIA, 4 (0.7%) had a coronary event, and 24 (4.0%) had died. Recurrent stroke occurred in 19.2% of patients with index stroke caused by large-artery disease, 4.9% with small-vessel disease, 8.2% with cardioembolic cause, 5.6% with cryptogenic cause, and 12.8% with other and undetermined cause combined.[45]
- Recurrent stroke is associated with a greater number of risk factors and a higher incidence of large-artery atherosclerosis than the first stroke.[46]
- Among 1626 first-ever stroke patients in the South London Stroke Register,[47] first stroke recurrence rates (95% CI) during the first, second, third, fourth, and fifth years were 8% (6.5%–9.8%), 3.3% (2.2%–4.9%), 3.5% (2.1%–5.8%), 1.2% (0.4%–3.7%), and 1.8% (0.4%–7.4%), respectively. Cumulative risks of first stroke recurrence (95% CI) were 2.6% (1.9%–3.7%) at 3 months, 8.0% (6.5%–9.8%) at 1 year, 14.1% (11.8%–16.7%) at 3 years, and 16.6% (13.5%–20.4%) at 5 years.[47]
- During a median 5.3 years of follow-up among 987 ARIC participants with first-ever strokes, there were 183 recurrent strokes among 147 participants. Approximately 70% of recurrent strokes were of the same subtype; however, 28% were the same when the index stroke was lacunar. One-year stroke recurrence rates by index subtype were 7.9% for thrombotic, 6.5% for cardioembolic, and 6.5% for lacunar events.[48]
- In a long term follow-up study of recurrent vascular events among 724 first-ever TIA, stroke, or ICH patients aged 18 to 50 years in the Netherlands, cumulative 20-year risk of recurrent stroke was 17.3% (95% CI, 9.5%–25.1%) after TIA, 19.4% (95% CI, 14.6%–24.3%) after ischemic stroke, and 9.8% (95% CI, 1.0%–18.7%) after ICH.[49]
- Among 1867 stroke patients aged 18 to 45 years in IPSYS, at 10 years the cumulative risk of brain ischemia was 14.0% (95% CI, 11.4%–17.1%).[50]

Stroke Mortality

(See Table 14-1 and Charts 14-6 and 14-7.)

See "Factors influencing the decline in stroke mortality: a statement from the American Heart Association/American

Stroke Association"[51] for more in-depth coverage of factors contributing to the decline in stroke mortality over the past several decades.

- In 2013[52]
  - —On average, every 4 minutes, someone died of a stroke.
  - —Stroke accounted for ≈1 of every 20 deaths in the United States.
  - —When considered separately from other CVDs, stroke ranks No. 5 among all causes of death, behind diseases of the heart, cancer, CLRD, and unintentional injuries/accidents.
  - —The number of deaths with stroke as an underlying cause was 128 978; any-mention mortality was 219 335; and the age-adjusted death rate for stroke as an underlying cause of death was 36.2 per 100 000, whereas any-mention cause of death was 61.5 per 100 000.
  - —Approximately 59% of stroke deaths occurred outside of an acute care hospital.
  - —More women than men die of stroke each year because of the larger number of elderly women. Women accounted for 58% of US stroke deaths in 2013.
  - —From 2003 to 2013, the age-adjusted stroke death rate decreased 33.7%, and the actual number of stroke deaths declined 18.2%.
- Conclusions about changes in stroke death rates from 1981 to 2013 are as follows[53]:
  - —There was a slightly greater decline in age-adjusted stroke death rates in men (−61.4%) than in women (−58.9%) aged ≥18 years.
  - —Stroke death rates declined more among people aged ≥65 years (−54.1%; from 534.1 to 245.2 per 100 000) than those aged 45 to 64 years (−53.6%; from 43.5 to 20.2 per 100 000) or those aged 18 to 44 years (−45.9%; from 3.7 to 2.0 per 100 000).
  - —Age-adjusted stroke death rates for adults aged ≥18 years declined by ≈50% or more among all racial groups; however, in 2013, rates remained higher among blacks (65.7 per 100 000) than other races, including whites (46.9 per 100 000) and Asians (39.6 per 100 000).
- There are substantial geographic disparities in stroke mortality, with higher rates in the southeastern United States, known as the "stroke belt." This area is usually defined to include the 8 southern states of North Carolina, South Carolina, Georgia, Tennessee, Mississippi, Alabama, Louisiana, and Arkansas. These geographic differences have existed since at least 1940,[54] and despite some minor shifts,[55] they persist.[56–58] Within the stroke belt, a "buckle" region along the coastal plain of North Carolina, South Carolina, and Georgia has been identified with an even higher stroke mortality rate than the remainder of the stroke belt. The overall average stroke mortality is ≈20% higher in the stroke belt than in the rest of the nation and ≈40% higher in the stroke buckle.[59]
- In examining trends in stroke mortality by US census divisions from 1999 to 2007 for people ≥45 years of age, the rate of decline varied by geographic region and race/ethnic group. Among black and white women and white men, rates declined by ≥2% annually in every census division, but among black men, rates declined little in the East and West South Central divisions.[60]
- On the basis of national death statistics for the time period 1990 to 2009, stroke mortality rates among American Indian and Alaska Native people were higher than among whites for both men and women in contract health services delivery area counties in the United States and were highest in the youngest age groups (35–44 years old). Stroke mortality rates and the rate ratios for American Indians/Alaska Natives to whites varied by region, with the lowest in the Southwest and the highest in Alaska. Starting in 2001, rates among American Indian/Alaska Native people decreased in all regions.[61]
- In 2002, death certificate data showed that the mean age at stroke death was 79.6 years; however, males had a younger mean age at stroke death than females. Blacks, American Indian/Alaska Natives, and Asian/Pacific Islanders had younger mean ages than whites, and the mean age at stroke death was also younger among Hispanics than non-Hispanics.[62]
- Data from the ARIC study (1987–2011; 4 US cities) showed that the cumulative all-cause mortality rate after a stroke was 10.5% at 30 days, 21.2% at 1 year, 39.8% at 5 years, and 58.4% at the end of follow-up. Mortality rates were higher after an incident hemorrhagic stroke (67.9%) than ischemic stroke (57.4%). Age-adjusted mortality after an incident stroke decreased over time (absolute decrease of 8.1 deaths per 100 strokes after 10 years), which was mainly attributed to the decrease in mortality among those aged ≤65 years (absolute decrease of 14.2 deaths per 100 strokes after 10 years).[15]
- Data from the BASIC Project showed there was no change in ICH case fatality or long-term mortality from 2000 to 2010 in a South Texas community. Yearly age-, sex-, and ethnicity-adjusted 30-day case fatality ranged from a low of 28.3% (95% CI, 19.9%–40.3%) in 2006 to 46.5% (95% CI, 35.5%–60.8%) in 2008.[16]
- A report released by the CDC in collaboration with the Centers for Medicare & Medicaid Services, the *Atlas of Stroke Hospitalizations Among Medicare Beneficiaries*, found that in Medicare beneficiaries over the time period 1995 to 2002, the 30-day mortality rate varied by age: 9% in patients 65 to 74 years of age, 13.1% in those 74 to 84 years of age, and 23% in those ≥85 years of age.[56]

Stroke Risk Factors

(See Table 14-2 and Chart 14-8.)

For prevalence and other information on any of these specific risk factors, refer to the specific risk factor chapters.

High BP

(See Chapter 9 for more information.)

- Median SBP declined 16 mm Hg between 1959 and 2010 for different age groups in association with large accelerated reductions in stroke mortality. In clinical trials, antihypertensive therapy has been associated with reductions in stroke incidence, with an average 41% reduction in stroke risk with SBP reductions of 10 mm Hg.[51]
- BP is a powerful determinant of risk for both ischemic stroke and intracranial hemorrhage.

—Approximately 77% of those who have a first stroke have BP >140/90 mm Hg (NHLBI unpublished estimates from ARIC, CHS, and FHS Cohort and Offspring studies).
—Diabetic subjects with BP <120/80 mm Hg have approximately half the lifetime risk of stroke of subjects with hypertension. The treatment and lowering of BP among diabetic hypertensive individuals was associated with a significant reduction in stroke risk.[63]

- In the REGARDS study (NINDS), between the ages of 45 and 64 years (an age group in which African Americans are at 2 to 3 times the risk of stroke as whites), ≈40% of the excess stroke risk in African Americans is attributable to traditional stroke risk factors, with levels of SBP accounting for approximately one half of this impact.[64] For each 10 mm Hg increase in levels of SBP, the increased stroke risk in whites is ≈8%[65]; however, a similar 10 mm Hg increase in SBP in African Americans is associated with a 24% increase in stroke risk, an impact 3 times greater than in whites.[66]
- Cross-sectional baseline data from the SPS3 trial showed that more than half of all patients with symptomatic lacunar stroke had uncontrolled hypertension at 2.5 months after stroke.[67]
- A meta-analysis of 19 prospective cohort studies (including 762 393 participants) found that prehypertension is associated with incident stroke. The risk is particularly noted in those with BP values in the higher prehypertension range.[68]
- In cross-sectional analysis from the REGARDS study (NINDS), blacks with hypertension were more aware of their HBP and more frequently received treatment for it than whites but were less likely than whites to have their BP controlled.[69] In the SPS3 trial, black participants were more likely to have SBP ≥150 mm Hg at both study entry (40%) and end-study visit (17%; mean follow-up, 3.7 years) than whites (9%) and Hispanics (11%) at end-study visit.[65]
- The higher stroke risk for the stroke belt compared with other regions does not appear to be attributable to hypertension management, because treatment and control rates were similar for the 2 geographic areas.[69]
- Several studies have shown significantly lower rates of recurrent stroke with lower BPs. Most recently, the BP-reduction component of the SPS3 trial showed that targeting an SBP <130 mm Hg was likely to reduce recurrent stroke by ≈20% (P=0.08) and significantly reduced ICH by two thirds.[70]

Diabetes Mellitus

(See Chapter 10 for more information.)

- DM increases ischemic stroke incidence at all ages, but this risk is most prominent (risk ratio for ischemic stroke conferred by DM >5) before 65 years of age in both blacks and whites. According to data from the GCNKSS in 2005, the risk ratio for ischemic stroke in blacks <65 years of age was 5.2 compared with 12.0 for whites; the trend for greater risk conferred by DM at age <65 years in whites was noted in all 3 prior study periods. Overall, ischemic stroke patients with DM are younger, more likely to be black, and more likely to have HBP, MI, and high cholesterol than nondiabetic patients.[71]
- In people with a history of TIA or minor stroke, impaired glucose tolerance nearly doubled the stroke risk compared with those with normal glucose levels and tripled the risks for those with DM.[72]
- A meta-analysis of prospective RCTs of interventions that targeted people with prediabetes revealed a 24% relative risk reduction in fatal and nonfatal strokes (HR, 0.76; 95% CI, 0.58–0.99).[73]
- Data from the US Nationwide Inpatient Sample revealed that from 1997 to 2006, the absolute number of acute ischemic stroke hospitalizations declined by 17% (from 489 766 in 1997 to 408 378 in 2006); however, the absolute number of acute ischemic stroke hospitalizations with comorbid DM rose by 27% (from 97 577 [20%] in 1997 to 124 244 [30%] in 2006). The rise in comorbid DM was more pronounced in individuals who were relatively younger, black or "other" race, on Medicaid, or admitted to hospitals located in the South. Factors independently associated with higher odds of DM in acute ischemic stroke patients were black or "other" (versus white) race, CHF, peripheral vascular disease, and history of MI, renal disease, or hypertension.[74]
- A population-based study of 12 375 first-ever stroke patients 25 to 74 years old who were followed up for ≤23 years found that diabetic patients had a higher risk of death than nondiabetic patients (adjusted HR, 1.67; 95% CI, 1.58–1.76). The reduced survival of diabetic stroke patients was more pronounced in women (P=0.02) and younger individuals (P<0.001).[75]
- A retrospective analysis of diabetic patients with acute ischemic stroke revealed that those who had been taking and continued taking sulfonylureas were less likely to experience symptomatic hemorrhagic transformation than those who did not take sulfonylureas (P=0.016).[76]
- The ACCORD study showed that in patients with type 2 DM, targeting SBP to <120 mm Hg did not reduce the rate of cardiovascular events compared with subjects in whom the SBP target was <140 mm Hg, except for the end point of stroke, for which intensive therapy reduced the risk of any stroke (HR, 0.59; 95% CI, 0.39–0.89) and nonfatal stroke (HR, 0.63; 95% CI, 0.41–0.96).[63]
- ONTARGET revealed that in both patients with and without DM, the adjusted risk of stroke continued to decrease down to achieved SBP values of 115 mm Hg, whereas there was no benefit for other fatal or nonfatal cardiovascular outcomes below an SBP of 130 mm Hg.[77]

Disorders of Heart Rhythm

(See Chapter 16 for more information.)

- AF is a powerful risk factor for stroke, independently increasing risk ≈5-fold throughout all ages. The percentage of strokes attributable to AF increases steeply from 1.5% at 50 to 59 years of age to 23.5% at 80 to 89 years of age.[78,79]
- Because AF is often asymptomatic[80,81] and likely frequently undetected clinically,[82] the stroke risk attributed to AF may be substantially underestimated.[83] Screening for AF in patients with cryptogenic stroke or TIA by use of outpatient telemetry for 21 to 30 days has resulted in an AF detection rate of 12% to 23%.[82–84]

- Among 2580 participants ≥65 years of age with hypertension in whom a cardiac rhythm device that included an atrial lead was implanted, 35% developed subclinical tachyarrhythmias (defined as an atrial rate ≥190 beats per minute that lasted ≥6 minutes). These subclinical events were independently associated with a 2.5-fold increased risk of ischemic stroke or systemic embolism.[85]
- Important risk factors for stroke in the setting of AF include advancing age, hypertension, HF, DM, previous stroke or TIA, vascular disease, and female sex.[86–88] Additional biomarkers, including high levels of troponin and BNP, increase the risk of stroke in the setting of AF independent of those well-established clinical characteristics.[89]

High Blood Cholesterol and Other Lipids

(See Chapter 8 for more information.)

For clarity, different types of cholesterol (TC, subfractions) are described here and are bolded in each bullet point. Overall, the association of each cholesterol subfraction with total stroke has shown inconsistent results, and the data are limited on associations with specific ischemic stroke subtypes.

- An association between **TC** and ischemic stroke has been found in some prospective studies[90–92] but not others.[93–95] Elevated **TC** is inversely associated in multiple studies with hemorrhagic stroke.[96]
- Data from the Honolulu Heart Program//NHLBI found that in Japanese men 71 to 93 years of age, low concentrations of **HDL-C** were more likely to be associated with a future risk of thromboembolic stroke than were high concentrations.[97] However, a meta-analysis of 23 studies performed in the Asia-Pacific Region showed no significant association between low **HDL-C** and stroke risk.[98] A Finish study of 27 703 men and 30 532 women followed up for >20 years for ischemic stroke found an independent inverse association of **HDL-C** with the risks of total and ischemic stroke in women.[95]
- In an analysis by the Emerging Risk Factors Collaboration of individual records on 302 430 people without initial vascular disease from 68 long-term prospective studies, HR for ischemic stroke was 1.12 (95% CI, 1.04–1.20) with **non-HDL-C**.[99] In a pooled analysis of CHS and ARIC, low **LDLC** was associated with an increased risk of ICH.[100]
- Among 13 951 patients in the Copenhagen Heart Study followed up for 33 years for ischemic stroke, increasing stepwise levels of nonfasting **triglycerides** were associated with increased risk of ischemic stroke in both men and women. In the Rotterdam study (n=9068), increasing quartiles of serum **triglycerides** were associated with a reduced risk of ICH.[101]

Smoking/Tobacco Use

(See Chapter 3 for more information.)

- Current smokers have a 2 to 4 times increased risk of stroke compared with nonsmokers or those who have quit for >10 years.[102,103]
- Cigarette smoking is a risk factor for ischemic stroke and SAH.[102–104]
- Smoking is perhaps the most important modifiable risk factor in preventing SAH, with the highest PAR of any SAH risk factor.[108]
- In a large Danish cohort study, among people with AF, smoking was associated with a higher risk of ischemic stroke/arterial thromboembolism or death, even after adjustment for other traditional risk factors.[109]
- Data support a dose-response relationship between smoking and risk of stroke across old and young age groups.[104,110]
- A meta-analysis comparing pooled data of ≈3.8 million smokers and nonsmokers found a similar risk of stroke associated with current smoking in women and men.[111]
- Discontinuation of smoking has been shown to reduce stroke risk across sex, race, and age groups.[110]
- Smoking may impact the effect of other stroke risk factors on stroke risk. For example, a synergistic effect appears to exist between SBP[112] and oral contraceptives[113,114] and the risk of stroke.
- Exposure to secondhand smoke, also termed *passive smoking* or *environmental tobacco smoke*, is a risk factor for stroke. Meta-analyses have estimated a pooled RR of 1.25 for exposure to spousal smoking (or nearest equivalent) and risk of stroke. A dose-response relationship between exposure to secondhand smoke and stroke risk was also reported.[115,116] Data from REGARDS support these findings; after adjustment for other stroke risk factors, the risk of overall stroke was increased 30% among nonsmokers who had secondhand smoke exposure during adulthood (95% CI, 0.02–0.67).[117] Data from another large-scale prospective cohort study of women in Japan showed that environmental tobacco smoke exposure at home during adulthood was associated with an increased risk of stroke mortality in those aged ≥80 years (HR, 1.24; 95% CI, 1.05–1.46).[118] Overall, the increased risk was most evident for SAH (HR, 1.66; 95% CI, 1.02–2.70) in all age groups.[118]

Physical Inactivity

(See Chapter 4 for more information.)

- Results from REGARDS found that participants reporting PA <4 times per week had a 20% increased risk of incident stroke over a mean of 5.7 years compared with those exercising ≥4 times per week. This relationship, which was more pronounced in men than in women, may be explained in large part by the effect of PA on reducing traditional risk factors, such as obesity and DM.[119]
- Over a mean follow-up of 17 years, the ARIC study found a significant trend among African-Americans toward reduced incidence of stroke with increasing level of PA; a similar trend was observed for Caucasians in the study, although it was not statistically significant. Data from this study showed that although the highest levels of activity were most protective, even modest levels of PA appeared to be beneficial.[120]
- In NOMAS, a prospective cohort that included white, black, and Hispanic adults in an urban setting followed up for a median of 9 years, moderate to vigorous leisure-time PA was associated with an overall 35% reduction in risk of ischemic stroke.[121]
- In the Aerobics Center Longitudinal Study of participants who underwent evaluation at the Cooper Clinic in Dallas,

TX (46 405 men and 15 282 women), investigators found that cardiorespiratory fitness as measured by exercise treadmill testing was associated with a reduced risk of fatal and nonfatal stroke. Investigators noted that the effect was mainly notable for a higher intensity level of fitness achieved (7 to 8 maximum metabolic equivalents).[122] A prospective cohort study of 22 841 men and 24 880 women in Finland found a similar dose-response–independent protective effect from vigorous leisure-time PA on ischemic stroke, ICH, and SAH. The effect was more modest for commuting-time PA and was no longer present after adjustment for leisure-time PA.[123]

- Timing of PA in relation to stroke onset has also been examined in several studies. In a hospital-based case-control study from Heidelberg, Germany, recent activity (within the prior months) was associated with reduced odds of having a stroke or TIA, whereas sports activity during young adulthood that was not continued showed no benefit.[124] In a Danish case-control study, ischemic stroke patients were less physically active in the week preceding the stroke than age- and sex-matched control subjects, with the highest activity scores associated with the greatest reduction in odds of stroke.[125]
- Several recent prospective studies found associations of PA and stroke risk in women. In the Million Women study, a prospective cohort study among women in England and Scotland, over an average follow-up of 9 years, self-report of any PA at baseline was associated with reduced risk of any stroke, as well as stroke subtypes; however, more frequent or strenuous activity was not associated with increased protection against stroke.[126] Similarly, a low level of leisure-time PA was associated with a 1.5 times higher risk of stroke and a nearly 2.5 times higher risk of fatal stroke compared with intermediate to high levels of activity in a cohort of ≈1500 women followed up for up to 32 years.[45] The EPIC-Heidelberg cohort included 25 000 men and women and identified stroke outcomes over a mean of 13 years of follow-up. Among women, participation in any level of PA was associated with a nearly 50% reduction in stroke risk compared with inactivity; no similar pattern was seen for men.[127]
- A dose-response effect was seen for total number of hours spent walking per week, and increased walking time was associated with reduced risk of incident stroke among 4000 men in the British Regional Heart Study. Those reporting ≥22 hours of walking per week had one third the risk of incident stroke as those who walked <4 hours per week. No clear association between walking speed or distance walked was seen in this study.[128]

Nutrition

(See Chapter 5 for more information.)

- Adherence to a Mediterranean-style diet that was higher in nuts and olive oil was associated with a reduced risk of stroke (HR, 0.54; 95% CI, 0.35–0.84) in a randomized clinical trial conducted in Spain. The protective benefit of the Mediterranean diet observed was greater for strokes than for MI, but stroke subtype was not available.[129]
- In the Nurses Health and Health Professionals Follow-up Studies, each 1-serving increase in sugar-sweetened soda beverage was associated with a 13% increased risk of ischemic stroke but not hemorrhagic stroke. Conversely, each 1-serving increase in low-calorie or diet soda was associated with a 7% increased risk of ischemic stroke and 27% increased risk of hemorrhagic stroke.[130]
- A meta-analysis of >94 000 people with 34 817 stroke events demonstrated that eating ≥5 servings of fish per week versus eating <1 serving per week was associated with a 12% reduction in stroke risk; however, these results were not consistent across all cohort studies.[131]
- According to registry data from Sweden, people eating ≥7 servings of fruits and vegetables per day had a 19% reduced risk of stroke compared with those only eating 1 serving per day. This effect was only seen in people who did not have hypertension.[132]

Family History and Genetics

(See Chapter 7 for more information.)

- In the FHS, a documented parental ischemic stroke by the age of 65 years was associated with a 3-fold increase in ischemic stroke risk in offspring, even after adjustment for other known stroke risk factors. The absolute magnitude of the increased risk was greatest in those in the highest quintile of the FRS. By age 65 years, people in the highest FRS quintile with an early parental ischemic stroke had a 25% risk of stroke compared with a 7.5% risk of ischemic stroke for those without such a history.[133]
- The gene region *HDAC9* has been associated at genome-wide levels of significance with large-vessel ischemic stroke and replicated in independent samples.[134,135]
- The *PMF1*/*BGLAP* region has been associated at a genome-wide level with nonlobar ICH and replicated in an independent sample.[136]
- Apolipoprotein E alleles have been associated at a genome-wide level with lobar ICH and replicated in an independent sample.[137]
- *PITX2* has been associated at a genome-wide level with cardioembolic ischemic stroke, AF, and intracranial aneurysm and replicated in an independent sample.[135,138]

Chronic Kidney Disease

(See Chapter 12 for more information.)

- The CHS (NHLBI) showed that people with creatinine ≥1.5 mg/dL were at increased risk for stroke, with an adjusted HR of 1.77 (95% CI, 1.08–2.91).[139]
- Participants in REGARDS with a reduced eGFR were also shown to have increased risk of stroke symptoms,[140] and a meta-analysis of >280 000 patients showed a 43% increased incident stroke risk among patients with a GFR <60 $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$.[141]
- In a study of 539 287 Swedish men and women followed up for 12 years,[142] HRs for ICH were as follows: for GFR 60 to 90 $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$ (mild), 1.04 (95% CI, 0.93–1.15); for GFR 30 to 60 $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$ (moderate), 1.26 (95% CI, 0.96–1.64); and for GFR 15 to 30 $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$ (severe impairment), 2.31 (95% CI, 1.10–4.87). Among 128 patients with ICH, the presence of GFR <45 $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$ was associated with larger, lobar hematomas and poor outcome.[143]

- A urinary albumin-to-creatinine ratio >30 mg/g was associated with a 40% increased risk of stroke in black participants but not white participants in the REGARDS study.[144]
- A pooled analysis of 4 prospective community-based cohorts (ARIC, MESA, CHS, and PREVEND) including 29 595 participants showed that low eGFR (45 $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$) was significantly associated with increased risk of ischemic stroke (HR, 1.30; 95% CI, 1.01–1.68) but not hemorrhagic stroke (HR, 0.92; 95% CI, 0.47–1.81) compared with normal GFR (95 $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$). A high albumin-to-creatinine ratio of 300 mg/g was associated with both ischemic stroke (HR, 1.62; 95% CI, 1.27–2.07) and hemorrhagic stroke (HR, 2.57; 95% CI, 1.37–4.83) compared with 5 mg/g.[145]
- In the Taiwan National Health Insurance Research Database, after adjustment for baseline comorbid features, dialysis patients had higher risks of hemorrhagic stroke (HR 6.83 [95% CI, 5.89–7.92] and 6.15 [95% CI, 4.83–7.84] for hemodialysis and peritoneal dialysis, respectively) and ischemic strokes (HR 2.88 [95% CI, 2.60–3.19] and 3.21 [95% CI, 2.69–3.83] for hemodialysis and peritoneal dialysis, respectively) than the age- and sex-matched reference cohort.[146]
- Among patients registered in the Scottish Stroke Care Audit, 32% of the 2520 stroke patients admitted to 2 teaching hospitals over 3 years had renal dysfunction (eGFR <45 $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$). Stroke patients admitted with renal dysfunction were more likely to die in the hospital (OR, 1.59; 95% CI, 1.26–2.00).[147]

Risk Factor Issues Specific to Women

See the "Guidelines for the prevention of stroke in women: a statement for healthcare professionals from the American Heart Association/American Stroke Association" for more in-depth coverage of stroke risk factors unique to women.[148]

- On average, women are ≈4 years older at stroke onset than men (≈75 years compared with 71 years).[149]
- In the setting of AF, women have a significantly higher risk of stroke than men.[150–154]
- Analysis of data from the FHS found that women with natural menopause before 42 years of age had twice the ischemic stroke risk of women with natural menopause after 42 years of age.[155] However, no association was found between age at natural menopause and risk of ischemic or hemorrhagic stroke in the Nurse's Health Study.[156]
- Overall, randomized clinical trial data indicate that the use of estrogen plus progestin, as well as estrogen alone, increases stroke risk in postmenopausal, generally healthy women and provides no protection for postmenopausal women with established CHD[157–160] and recent stroke or TIA.[161]
- In a nested case-control study of the United Kingdom's General Practice Research Database, stroke risk was not increased for users of low-dose (≤50 μg) estrogen patches (RR, 0.81; 95% CI, 0.62–1.05) but was increased for users of high-dose (>50 μg) patches (RR, 1.89; 95% CI, 1.15–3.11) compared with nonusers.[162]
- Low-estrogen-dose oral contraceptives are associated with a 93% increased risk of ischemic stroke, but the absolute increased risk is small (4.1 ischemic strokes per 100 000 nonsmoking, normotensive women).[163,164]
- Migraine with aura is associated with ischemic stroke in younger women, particularly if they smoke or use oral contraceptives. The combination of all 3 factors increases the risk ≈9-fold compared with women without any of these factors.[165,166]
- In the Baltimore-Washington Cooperative Young Stroke Study, the risk of ischemic stroke or ICH during pregnancy and the first 6 weeks after giving birth was 2.4 times greater than for nonpregnant women of similar age and race. The excess risk of stroke (all types except SAH) attributable to the combined pregnancy/postpregnancy period was 8.1 per 100 000 pregnancies.[167]
- Analyses of the US Nationwide Inpatient Sample from 1994 to 1995 and from 2006 to 2007 show a temporal increase in the proportion of pregnancy hospitalizations that were associated with a stroke, with a 47% increase for antenatal hospitalizations and an 83% increase for postpartum hospitalizations. Increases in the prevalence of HD and hypertensive disorders accounted for almost all the increase in postpartum stroke hospitalizations but not the antenatal stroke hospitalizations.[90]
- Preeclampsia is a risk factor for ischemic stroke remote from pregnancy.[168] The increase in stroke risk related to preeclampsia may be mediated by later risk of hypertension and DM.[169]

Sleep Apnea

- The prevalence of sleep-disordered breathing, defined as an AHI ≥5, has been estimated to be 34% for men and 17% for women aged 30 to 70 years.[170] The age-adjusted prevalence of mild (AHI ≥5), moderate (AHI ≥15), and severe (AHI ≥30) sleep-disordered breathing in the US Hispanic/Latino population has been estimated to be 26%, 10%, and 4%, respectively.[171]
- Sleep apnea is common after stroke, with prevalence in excess of 50%.[172,173]
- In the Sleep Heart Health Study, obstructive sleep apnea measured by the obstructive AHI was associated with risk of incident ischemic stroke in men after adjustment for confounders (P=0.016 for linear trend associated with quartiles of AHI) but not in women. Compared with men in the lowest quartile of AHI, men in the highest quartile (AHI >19) had an adjusted HR of 2.9 (95% CI, 1.1–7.4).[174]
- In a prospective analysis of nationwide databases of the entire Danish population from 2000 to 2011, risk of ischemic stroke was significantly higher in those with sleep apnea than in the general population (RR, 1.50; 95% CI, 1.35–1.66).[175]
- In a meta-analysis of 5 studies, obstructive sleep apnea was associated with incident stroke, with an OR of 2.2 (95% CI, 1.6–3.2). Similar results were found in a second meta-analysis that included additional studies (OR, 2.1; 95% CI, 1.5–2.9).[176,177]
- In a population-based stroke study, acute infarction involving the brainstem was associated with the presence of sleep-disordered breathing, defined as an AHI ≥10, with an OR of 3.76 (95% CI, 1.44–9.81) after adjustment for demographics, risk factors, and stroke severity.[178] In this same study, ischemic stroke subtype was not found to be

associated with the presence or severity of sleep-disordered breathing.[179]
- Obstructive sleep apnea is associated with higher poststroke mortality[180–182] and worse functional outcome.[183]
- No definitive study has been conducted to determine whether treatment with continuous positive airway pressure prevents stroke or improves poststroke outcomes.

Psychosocial Risk Factors

- Among 6019 adults followed up for a mean of 16.3 years from the first NHANES, higher levels of anxiety symptoms were associated with increased risk of incident stroke after adjustment for demographic, cardiovascular, and behavioral risk factors (HR, 1.14; 95% CI, 1.03–1.25). This association remained significant with further adjustment for depressive symptoms.[184]
- In the Chicago Health and Aging Project, higher psychological distress was associated with higher stroke mortality (HR, 1.29; 95% CI, 1.10–1.52) and incident hemorrhagic strokes (HR, 1.70; 95% CI, 1.28–2.25) among 4120 adults after risk adjustment for age, sex, race, and stroke risk factors.[185]
- Depression was associated with a nearly 2-fold increased odds of stroke after adjustment for age, socioeconomic status, lifestyle, and physiological risk factors (OR, 1.94; 95% CI, 1.37–2.74) in a cohort of 10547 women aged 47 to 52 years who were followed up for 12 years as part of the Australian Longitudinal Study on Women's Health.[186]
- In a meta-analysis of 17 community-based or population-based prospective studies published between 1994 and 2010 involving 206641 participants, people with a history of depression experienced a 34% higher risk for the development of subsequent stroke after adjustment for potential confounding factors (pooled RR, 1.34; 95% CI, 1.17–1.54); however, substantial between-study heterogeneity was noted. Associations were similar for men and women.[187]
- A meta-analysis of 28 prospective cohort studies comprising 317540 participants with a follow-up period that ranged from 2 to 29 years found that depression was prospectively associated with an increased risk of total stroke (pooled HR, 1.45; 95% CI, 1.29–1.63), fatal stroke (pooled HR, 1.55; 95% CI, 1.25–1.93), and ischemic stroke (pooled HR, 1.25; 95 CI, 1.11–1.40).[188]

Awareness of Stroke Warning Signs and Risk Factors

- In the 2009 NHIS, 51.2% of subjects were aware of 5 stroke warning symptoms and would first call 9-1-1 if they thought that someone was having a stroke. Awareness of all 5 stroke warning symptoms and calling 9-1-1 was higher among whites than blacks and Hispanics (55.9%, 47.1%, and 36.5%, respectively), women than men (53.6% versus 48.6%), and people with higher versus lower educational attainment (59.0% for people with a bachelor's degree or more compared with 51.4% for people with a high school diploma or some college and 36.7% for those who had not received a high school diploma; unpublished NHLBI tabulation).
- In the BRFSS from 2005 (n=71994), 43.6% of respondents were aware of the 5 principal stroke symptoms, but only 18.6% responded correctly when they were also asked to identify that chest pain was not a stroke symptom. Respondents who were white and college educated were more likely to identify stroke-related symptoms correctly, and there was significant geographic variability (highest proportion of correct responses in Minnesota, Virginia, and Iowa; lowest in Louisiana, Oklahoma, and Tennessee).[189]
- A study was conducted of patients admitted to an ED with possible stroke to determine their knowledge of the signs, symptoms, and risk factors of stroke. Of the 163 patients able to respond, 39% did not know a single sign or symptom. Patients ≥65 years of age were less likely than those <65 years old to know a sign or symptom of stroke (28% versus 47%), and 43% did not know a single risk factor. Overall, almost 40% of patients did not know the signs, symptoms, and risk factors for stroke.[190]
- A study of patients who had experienced a stroke found that only 60.5% were able to accurately identify 1 stroke risk factor and that 55.3% were able to identify 1 stroke symptom. Patients' median delay time from onset of symptoms to admission in the ED was 16 hours, and only 31.6% accessed the ED in <2 hours. Analysis showed that the appearance of nonmotor symptoms as the primary symptom and nonuse of the 9-1-1 system were significant predictors of delay >2 hours. Someone other than the patient made the decision to seek treatment in 66% of the cases.[191]
- Spanish-speaking Hispanics are less likely to know all stroke symptoms than English-speaking Hispanics, non-Hispanic blacks, and non-Hispanic whites. Lack of English proficiency is strongly associated with lack of stroke knowledge among Hispanics.[192]
- A study of CVD awareness performed by the AHA among women in the United States who were >75 years old (n=1205) showed that low proportions of women identified severe headache (23%), dizziness (20%), and vision loss/changes (18%) as stroke warning symptoms.[193]

Aftermath

(See Charts 14-9 through 14-11.)

- Stroke is a leading cause of serious long-term disability in the United States (Survey of Income and Program Participation, a survey of the US Census Bureau).[194]
- Stroke was among the top 18 diseases contributing to years lived with disability in 2010; of these 18 causes, only the age-standardized rates for stroke increased significantly between 1990 and 2010 ($P<0.05$).[195]
- Among Medicare patients discharged from the hospital after stroke, ≈45% return directly home, 24% are discharged to inpatient rehabilitation facilities, and 31% are discharged to skilled nursing facilities. Of stroke patients returning directly home, 32% use home healthcare services.[196]
- The readmission rate for Medicare fee-for-service beneficiaries with stroke in 2006 was 14.4%.[197]
- The 30-day hospital readmission rate after discharge from postacute rehabilitation for stroke is 12.7% among fee-for-service Medicare patients. The mean rehabilitation length of stay for stroke is 14.6 days.[198]

- Visual impairments persist in 21% of stroke survivors 90 days after stroke.[199]
- Initial severity of upper limb weakness is the best predictor of ultimate recovery of upper limb motor function.[200]
- Data from the BRFSS (CDC) 2005 survey on stroke survivors in 21 states and the District of Columbia found that 30.7% of stroke survivors received outpatient rehabilitation. The findings indicated that the prevalence of stroke survivors receiving outpatient stroke rehabilitation was lower than would be expected if clinical practice guideline recommendations for all stroke patients had been followed.[201]
- After stroke, women have greater disability than men. A cross-sectional analysis of 5888 community-living elderly people (>65 years of age) in the CHS who were ambulatory at baseline found that women were half as likely to be independent in activities of daily living after stroke, even after controlling for age, race, education, and marital status.[202] A prospective study from a Michigan-based stroke registry found that women had a 63% lower probability of achieving independence in activities of daily living 3 months after discharge, even after controlling for age, race, subtype, prestroke ambulatory status, and other patient characteristics.[203]
- A national study of inpatient rehabilitation after first stroke found that blacks were younger, had a higher proportion of hemorrhagic stroke, and were more disabled on admission. Compared with non-Hispanic whites, blacks and Hispanics also had a poorer functional status at discharge but were more likely to be discharged to home rather than to another institution, even after adjustment for age and stroke subtype. After adjustment for the same covariates, compared with non-Hispanic whites, blacks also had less improvement in functional status per inpatient day.[204]
- Blacks were less likely to report independence in activities of daily living and instrumental activities of daily living than whites 1 year after stroke after controlling for stroke severity and comparable rehabilitation use.[205]
- In a study of 90-day poststroke outcomes among ischemic stroke patients in the BASIC Project, Mexican Americans scored worse on neurological, functional, and cognitive outcomes than non-Hispanic whites after multivariable adjustment.[206]

Stroke in Children

- On the basis of pathogenic differences, pediatric strokes are typically classified as either perinatal (occurring at ≤28 days of life and including in utero strokes) or (later) childhood.
- Estimates of the overall annual incidence of stroke in US children are 6.4 per 100 000 children (0 to 15 years) in 1999 in the GCNKSS[207] and 4.6 per 100 000 children (0 to 19 years) in 1997 to 2003 in a northern California population.[208] Approximately half of all incident childhood strokes are hemorrhagic.[207–209]
- The prevalence of perinatal strokes is 29 per 100 000 live births, or 1 per 3500 live births in the 1997 to 2003 Kaiser Permanente of Northern California population.[208]
- A history of infertility, preeclampsia, prolonged rupture of membranes, and chorioamnionitis are independent maternal risk factors for perinatal arterial ischemic stroke.[210] However, maternal health and pregnancies are normal in most cases.[211]
- Diagnostic delays are more common in ischemic than hemorrhagic stroke in children, with a median time from symptom onset to diagnostic neuroimaging of 3 hours for hemorrhagic and 24 hours for ischemic stroke in a population-based study from the south of England.[212]
- The most common cause of arterial ischemic stroke in children is a cerebral arteriopathy, found in more than half of all cases.[213,214] Childhood arteriopathies are heterogeneous and can be difficult to distinguish from a partially thrombosed artery in the setting of a cardioembolic stroke; incorporation of clinical data and serial vascular imaging is important for diagnosis.[215]
- In a retrospective population-based study in northern California, 7% of childhood ischemic strokes and 2% of childhood hemorrhagic strokes were attributable to congenital HD. Congenital HD increased a child's risk of stroke 19-fold (OR, 19; 95% CI, 4.2–83). The majority of children with stroke related to congenital HD were outpatients at the time of the stroke.[216]
- In another study of the same northern Californian population, adolescents with migraine had a 3-fold increased odds of ischemic stroke compared with those without migraine (OR, 3.4; 95% CI, 1.2–9.5); younger children with migraine had no significant difference in stroke risk.[217]
- Head or neck trauma in the prior week is a strong risk factor for childhood arterial ischemic stroke (adjusted OR, 36; 95% CI, 5–281), present in 10% of cases. Exposure to minor infection in the prior month is another independent risk factor, present in one third of cases (adjusted OR, 3.9; 95% CI, 2.0–7.4).[218] The effect of infection on pediatric stroke risk is short-lived, lasting for days; 80% of infections preceding childhood stroke are respiratory.[219]
- Thrombophilias (genetic and acquired) are risk factors for childhood stroke, with summary ORs ranging from 1.6 to 8.8 in a meta-analysis.[220]
- In a prospective Swiss registry,[221] atherosclerotic risk factors were less common in children with arterial ischemic stroke than in young adults; the most common of these factors in children was hyperlipidemia (15%). However, an analysis of the Nationwide Inpatient Sample suggests a low but rising prevalence of these factors among US adolescents and young adults hospitalized for ischemic stroke (1995 versus 2008).[222]
- Compared with girls, US boys have a 25% increased risk of ischemic stroke and a 34% increased risk of ICH, whereas a study in the United Kingdom found no sex difference in childhood ischemic stroke.[223] Compared with white children, black children in both the United States and United Kingdom have a >2-fold risk of stroke.[224] The increased risk among blacks is not fully explained by the presence of sickle cell disease, nor is the excess risk among boys fully explained by trauma.[224]
- The excess ischemic stroke mortality in US black children compared with white children has diminished since 1998 when the STOP trial was published, which established a method for primary stroke prevention in children with sickle cell disease.[225]
- Among young adult survivors of childhood stroke, 37% had a normal modified Rankin score, 42% had mild deficits, 8% had

moderate deficits, and 15% had severe deficits.[226] Concomitant involvement of the basal ganglia, cerebral cortex, and posterior limb of the internal capsule predicts a persistent hemiparesis.[227]

- Survivors of childhood arterial ischemic stroke have, on average, low normal cognitive performance,[228,229] with poorest performance in visuoconstructive skills, short-term memory, and processing speed. Younger age at stroke and seizures, but not laterality of stroke (left versus right), predict worse cognitive outcome.[229]
- Compared with control children with asthma, childhood stroke survivors have greater impairments in adaptive behaviors, social adjustment, and social participation, even if their IQ is normal.[230] Severity of disability after perinatal stroke correlates with maternal psychosocial outcomes such as depression and quality of life.[231]
- Despite current treatment, at least 1 of 10 children with ischemic or hemorrhagic stroke will have a recurrence within 5 years.[232,233]
- Cerebral arteriopathies increase risk of recurrence,[234] with a 5-year recurrence risk as high as 60% among children with abnormal arteries on vascular imaging.[235] The recurrence risk after perinatal stroke, however, is negligible.[235]
- Among 59 long-term survivors of pediatric brain aneurysms, 41% developed new or recurrent aneurysm during a median follow-up of 34 years; of those, one third developed multiple aneurysms.[236]
- More than 25% of survivors of perinatal ischemic strokes develop delayed seizures within 3 years; babies with larger strokes are at higher risk.[237] The cumulative risk of delayed seizures after later childhood stroke is 13% at 5 years and 30% at 10 years.[238] Children with acute seizures (within 7 days of their stroke) have the highest risk for delayed seizures, >70% by 5 years after the stroke.[239]
- In a study of 111 pediatric stroke cases admitted to a single US children's hospital, the median 1-year direct cost of a childhood stroke (inpatient and outpatient) was ≈$50 000, with a maximum approaching $1 000 000. More severe neurological impairment after a childhood stroke correlated with higher direct costs of a stroke at 1 year and poorer quality of life in all domains.[240]
- A prospective study at 4 centers in the United States and Canada found that the median 1-year out-of-pocket cost incurred by the family of a child with a stroke was $4354 (maximum $38 666), which exceeded the median American household cash savings of $3650 at the time of the study and represented 6.8% of the family's annual income.[241]

Stroke in the Young

- In the NHIS, hospitalizations for ischemic stroke increased among adolescents and young adults (aged 5–44 years) between 1995 and 2008, whereas SAH hospitalizations decreased during that same period.[222]
- Approximately 10% of all strokes occur in individuals 18 to 50 years of age.[242]
- In the 2005 GCNKSS study period, the sex-adjusted incidence rate of first-ever stroke was 48 per 100 000 (95% CI, 42–53) among whites aged 20 to 54 years compared with 128 per 100 000 among blacks of the same age. Both races had a significant increase in the incidence rate from 1993/1994.[149]
- Among 20- to 54-year-olds in the 2005 GCNKSS, ischemic stroke was the most common stroke type, constituting 68.6% of all strokes, followed by ICH (16.9%), SAH (9.8%), and unknown pathogenesis (4.7%).[149]
- Vascular risk factors are common among stroke patients aged 20 to 54 years. During 2005, in the biracial GCNKSS, hypertension prevalence was estimated at 52%, hyperlipidemia at 18%, DM at 20%, CHD at 12%, and current smoking at 46% among stroke patients 20 to 54 years of age.[149]
- In the FUTURE study, the 30-day case fatality rate among stroke patients 18 to 50 years of age was 4.5%. One-year mortality among 30-day survivors was 1.2% (95% CI, 0.0%–2.5%) for TIA, 2.4% (95% CI, 1.2%–3.7%) for ischemic stroke, and 2.9% (95% CI, 0.0%–6.8%) for ICH.[243]
- In the FUTURE study, after a mean of 9 years of follow-up, 32% of young stroke patients had poor functional outcome, defined as a modified Rankin score >2.[244]

Stroke in the Very Elderly

- Stroke patients >85 years of age make up 17% of all stroke patients.[245]
- Very elderly patients have a higher risk-adjusted mortality,[246] have greater disability,[246] have longer hospitalizations,[247] receive less evidenced-based care,[248,249] and are less likely to be discharged to their original place of residence.[247,250]
- According to analyses from the US Nationwide Inpatient Sample, over the past decade, in-hospital mortality rates after stroke have declined for every age/sex group except men aged >84 years.[251]
- Over the next 40 years (2010–2050), the number of incident strokes is expected to more than double, with the majority of the increase among the elderly (aged ≥75 years) and minority groups.[252]
- A Danish stroke registry reported on 39 centenarians (age range 100–107 years) hospitalized with acute stroke. Although they had more favorable risk profiles than other age groups (lower prevalence of previous MI, stroke, and DM), their strokes were more severe and were associated with high 1-month mortality (38.5%).[253]

Organization of Stroke Care

- Among 30 947 patients hospitalized with acute ischemic stroke in the state of New York between 2005 and 2006, admission to a designated stroke center was associated with lower 30-day mortality (10.1% versus 12.5%; adjusted mortality difference, −2.5%; 95% CI, −3.6% to −1.4%) and greater use of thrombolytic therapy (4.8% versus 1.7%; adjusted difference, 2.2%; 95% CI, 1.6%–2.8%), but there was no difference in 30-day all-cause readmission or discharge to a skilled nursing facility.[254]
- A study using Medicare data found that among 6197 SAH and 31 272 ICH stroke discharges in 2006, patients treated at Joint Commission–certified primary stroke centers had lower 30-day risk-adjusted mortality than patients treated at noncertified centers (SAH OR, 0.66 [95% CI, 0.58–0.76]; ICH OR, 0.86 [95% CI, 0.80–0.92]), but no difference was seen for 30-day all-cause readmission.[255]

- A Cochrane review of 28 trials involving 5855 participants concluded that stroke patients who receive organized inpatient care in a stroke unit had better outcomes, including a decreased odds of mortality (median of 1 year; OR, 0.87; 95% CI, 0.69–0.94), death or institutionalized care (0.78; 95% CI, 0.68–0.89), and death or dependency (OR, 0.79; 95% CI, 0.68–0.90) than patients treated in an alternative form of inpatient care. The findings were independent of patient age, sex, initial stroke severity, or stroke type.[256]
- Data have shown a steady increase in the proportion of ischemic stroke patients who are treated with tPA therapy. For example, administrative data in 2009 found that between 3.4% and 5.2% of acute ischemic strokes were treated with tPA, which was approximately double the treatment rate observed in 2005.[257] Similarly, analysis of data from the GWTG-Stroke program demonstrated substantial increases in tPA treatment rates over the period from 2003 to 2011.[258]
- Analysis of tPA-treated patients in the GWTG-Stroke program between 2003 and 2009 found that the majority were not treated within the guideline-recommended interval of 60 minutes from hospital arrival and that this proportion had increased only modestly during this period (from 19% in 2003 to 29% in 2009).[259] Paradoxically, door-to-needle times were found to be inversely related to onset to arrival times; thus, tPA-treated patients who arrived earlier were less likely to receive treatment within 60 minutes of arrival.[260]
- Implementation of Target Stroke, a national quality improvement initiative to improve the timeliness of tPA administration, found that among 71 169 patients with acute ischemic stroke treated with tPA at 1030 GWTG-Stroke participating hospitals, participation in the program was associated with a decreased door-to-needle time, lower in-hospital mortality (OR, 0.89; 95% CI, 0.83–0.94) and intracranial hemorrhage (OR, 0.83; 95% CI, 0.76–0.91), and an increase in the percentage of patients discharged home (OR, 1.14; 95% CI, 1.09–1.19).[261]
- Approximately 70% of Medicare beneficiaries who are discharged with acute stroke use Medicare-covered postacute care,[262] with most receiving care from more than 1 type of setting.[263,264] The majority of stroke patients receive rehabilitation care in a skilled nursing facility after discharge (32%), followed by an inpatient rehabilitation facility (22%), and then home health care (15%).[265]
- The proportion of stroke patients not referred to any postacute care has increased in recent years,[265] with an analysis of 2006 Medicare data finding that proportion to be as high as 42%.[266]

Hospital Discharges/Ambulatory Care Visits

(See Table 14-1.)

- From 2000 to 2010, the number of inpatient discharges from short-stay hospitals with stroke as the first-listed diagnosis remained about the same, with discharges of 981 000 and 1 015 000, respectively (NHDS, NHLBI tabulation).[267]
- In 2011, there were 591 000 ED visits and 209 000 outpatient department visits with stroke as the first-listed diagnosis (NHAMCS, unpublished NHLBI tabulation). In 2012, physician office visits for a first-listed diagnosis of stroke totaled 2 381 000 (NAMCS, unpublished NHLBI tabulation).
- In 2010, men and women accounted for roughly the same number of hospital stays for stroke in the 18- to 44-year-old age group. Among people 45 to 64 years of age, 57.1% of stroke patients were men. After 65 years of age, women were the majority. Among people 65 to 84 years of age, 53.4% of stroke patients were women, whereas among those ≥85 years of age, women constituted 66.2% of all stroke patients.[268]
- A first-ever county-level *Atlas of Stroke Hospitalizations Among Medicare Beneficiaries* was released in 2008 by the CDC in collaboration with the Centers for Medicare & Medicaid Services. It found that the stroke hospitalization rate for blacks was 27% higher than for the US population in general, 30% higher than for whites, and 36% higher than for Hispanics. In contrast to whites and Hispanics, the highest percentage of strokes in blacks (42.3%) occurred in the youngest Medicare age group (65–74 years of age).[56]

Operations and Procedures

(See Chart 14-12.)

- In 2010, an estimated 100 000 inpatient endarterectomy procedures were performed in the United States. Carotid endarterectomy is the most frequently performed surgical procedure to prevent stroke (NHDS, NHLBI tabulation).
- Although rates of carotid endarterectomy have decreased between 1997 and 2010, the use of carotid stenting has increased dramatically (Nationwide Inpatient Sample, HCUP, AHRQ).
- The practice of carotid stenting in the United States is expanding, from <3% of all carotid artery revascularization procedures in 1998 to 13% in 2008.[269]
- The randomized CREST study compared carotid endarterectomy and stenting for symptomatic and asymptomatic carotid stenosis. There was no overall difference in the primary end point of stroke, MI, or death; however, carotid endarterectomy showed superiority with increasing age, with the crossover point at approximately age 70 years, and was associated with fewer strokes, which had a greater impact on quality of life than MI.[270,271]
- In-hospital mortality for carotid endarterectomy has decreased steadily from 1993 to 2012 (Nationwide Inpatient Sample, HCUP, AHRQ).
- In the Medicare population, in-hospital stroke rate and mortality are similar for carotid endarterectomy and carotid stenting.[272]
- Carotid stenting is associated with significantly higher costs than carotid endarterectomy in asymptomatic patients[273] and may be less cost-effective in general.[274]
- The percentage of patients undergoing carotid endarterectomy within 2 weeks of the onset of stroke increased from 13% in 2007 to 47% in 2010.[275]
- Several recent clinical trials reported improved functional outcome at 90 days among patients receiving endovascular treatment in conjunction with intravenous tPA for acute ischemic stroke caused by occlusions in the proximal anterior intracranial circulation versus tPA alone. In the SWIFT PRIME trial, thrombectomy with a stent retriever plus intravenous tPA reduced disability at 90 days over the entire range of scores on the modified Rankin scale (P<0.001). The rate of functional independence (modified Rankin

scale score 0–2) was higher in the intervention group than in the control group (60% versus 35%, $P<0.001$).[276]
- In patients with ischemic stroke with a proximal cerebral arterial occlusion and salvageable tissue on CT perfusion imaging in the EXTEND-IA trial, early thrombectomy with the Solitaire FR stent retriever, compared with alteplase alone, improved reperfusion, early neurological recovery, and functional outcome. Endovascular therapy, initiated at a median of 210 minutes after the onset of stroke, increased early neurological improvement at 3 days (80% versus 37%, $P=0.002$) and improved functional outcome at 90 days, with more patients achieving functional independence (score of 0–2 on the modified Rankin scale, 71% versus 40%; $P=0.01$).[277]
- Among patients with acute ischemic stroke with a proximal vessel occlusion in the ESCAPE trial, rapid endovascular treatment improved functional outcomes and reduced mortality. The rate of functional independence (90-day modified Rankin score of 0–2) was increased with the intervention (53.0% versus 29.3% in the control group, $P<0.001$).[278]
- Among patients with anterior circulation stroke in the REVASCAT trial, stent retriever thrombectomy reduced the severity of disability over the range of the modified Rankin scale (adjusted OR for improvement of 1 point, 1.7; 95% CI, 1.05–2.8) and led to higher rates of functional independence (a score of 0–2) at 90 days (43.7% versus 28.2%; adjusted OR, 2.1; 95% CI, 1.1–4.0).[279]

Cost

(See Table 14-1.)

- In 2011 to 2012 (average annual)[280]:
  - —The direct and indirect cost of stroke was $33.0 billion (MEPS, NHLBI tabulation).
  - —The estimated direct medical cost of stroke was $17.2 billion. This includes hospital outpatient or office-based provider visits, hospital inpatient stays, ED visits, prescribed medicines, and home health care.
  - — The mean expense per patient for direct care for any type of service (including hospital inpatient stays, outpatient and office-based visits, ED visits, prescribed medicines, and home health care) in the United States was estimated at $4830.[281]
- Between 2012 and 2030, total direct medical stroke-related costs are projected to triple, from $71.6 billion to $184.1 billion, with the majority of the projected increase in costs arising from those 65 to 79 years of age.[9]
- The total cost of stroke from 2005 to 2050, in 2005 dollars, is projected to be $1.52 trillion for non-Hispanic whites, $313 billion for Hispanics, and $379 billion for blacks. The per capita estimated cost of stroke is highest in blacks ($25 782), followed by Hispanics ($17 201) and non-Hispanic whites ($15 597). Loss of earnings is expected to be the highest cost contributor in each race/ethnic group.[282]
- During 2001 to 2005, the average cost for outpatient stroke rehabilitation services and medications the first year after inpatient rehabilitation discharge was $11 145. The corresponding average yearly cost of medication was $3376, whereas the average cost of yearly rehabilitation service utilization was $7318.[283]
- Recurrent stroke patients had 38% higher costs per patient 1 year after discharge from index hospitalization than new stroke patients.[284]
- In adjusted models that controlled for relevant covariates, the attributable 1-year cost of poststroke aphasia was estimated at $1703 in 2004 dollars.[285]
- Data from Sweden show that healthcare costs associated with stroke survivors with spasticity are 4-fold higher than for stroke survivors without spasticity.[286]
- The estimated cost of acute pediatric stroke in the United States was $42 million in 2003. The mean cost of short-term hospital care was $20 927 per discharge.[287]
- After adjustment for routine healthcare costs, the average 5-year cost of a neonatal stroke was $51 719 and that of a childhood stroke was $135 161. Costs among children with stroke continued to exceed those in age-matched control children even in the fifth year by an average of $2016.[288]

Global Burden of Stroke

Although global age-adjusted mortality rates for ischemic and hemorrhagic stroke decreased between 1990 and 2013, the absolute number of people who have strokes annually, as well as related deaths and DALYs lost, increased. The majority of global stroke burden is in low-income and middle-income countries.[289,290]

Prevalence

- In 2010, prevalence of stroke was 33 million, with 16.9 million people having a first stroke.[291]
- 5.2 million (31%) first strokes were in those <65 years of age.[291]

Incidence

- In 2010, there were an estimated 11.6 million events of incident ischemic stroke and 5.3 million events of incident hemorrhagic stroke, 63% and 80%, respectively, in low- and middle-income countries.[289]
- Between 1990 and 2010[289]:
  - —Incidence of ischemic stroke was significantly reduced by 13% (95% CI, 6%–18%) in high-income countries. No significant change was seen in low- or middle-income countries.
  - —Incidence of hemorrhagic stroke decreased by 19% in high-income countries. Rates increased by 22% in low- and middle-income countries, with a 19% increase in those aged <75 years.

Mortality

- In 2013[290]:
  - —There were 6.5 million stroke deaths worldwide, making stroke the second-leading global cause of death behind ischemic HD.
  - —Stroke deaths accounted for 11.8% of total deaths worldwide.

—The absolute number of stroke deaths increased 40.2% between 1990 and 2013; however, the age-standardized death rate decreased 22.5%.
—A total of 3.3 million individuals died of ischemic stroke and 3.2 million of hemorrhagic stroke.
—Age-standardized death rates decreased 19.6% and 25.9% for ischemic and hemorrhagic stroke, respectively, since 1990.

- In 2010, 39.4 million DALYs were lost because of ischemic stroke and 62.8 million because of hemorrhagic stroke (64% and 85%, respectively, in low- and middle-income countries).[289]
- In 2010, the mean age of stroke-related death in high-income countries was 80.4 years compared with 72.1 years in low- and middle-income countries.[292]
- Between 1990 and 2010, ischemic stroke mortality decreased 37% in high-income countries and 14% in low- and middle-income countries. Hemorrhagic stroke mortality decreased 38% in high-income countries and 23% in low- and middle-income countries.[289]

Table 14-1. Stroke

Population Group	Prevalence, 2012: Age ≥20 y	New and Recurrent Attacks, All Ages	Mortality, 2013: All Ages*	Hospital Discharges, 2010: All Ages	Cost, 2012
Both sexes	6 600 000 (2.6%)	795 000	128 978	1 015 000	$33.0 Billion
Males	3 000 000 (2.6%)	370 000 (46.5%)†	53 691 (41.6%)†	485 000	…
Females	3 600 000 (2.7%)	425 000 (53.5%)†	75 287 (58.4%)†	530 000	…
NH white males	2.2%	325 000‡	40 350	…	…
NH white females	2.5%	365 000‡	59 409	…	…
NH black males	4.2%	45 000‡	7266	…	…
NH black females	4.7%	60 000‡	8845	…	…
Hispanic males	2.8%	…	3841	…	…
Hispanic females	2.0%	…	4286	…	…
NH Asian or Pacific Islander	…	…	4147§	…	…
NH American Indian or Alaska Native	3.0%‖¶	…	569	…	…

Ellipses (…) indicate data not available; and NH, non-Hispanic.

*Mortality for Hispanic, American Indian or Alaska Native, and Asian and Pacific Islander people should be interpreted with caution because of inconsistencies in reporting Hispanic origin or race on the death certificate compared with censuses, surveys, and birth certificates. Studies have shown underreporting on death certificates of American Indian or Alaska Native, Asian and Pacific Islander, and Hispanic decedents, as well as undercounts of these groups in censuses.

†These percentages represent the portion of total stroke incidence or mortality that applies to males vs females.

‡Estimates include Hispanics and non-Hispanics. Estimates for whites include other nonblack races.

§Includes Chinese, Filipino, Hawaiian, Japanese, and other Asian or Pacific Islander.

‖National Health Interview Survey (2014), National Center for Health Statistics; data are weighted percentages for Americans ≥18 years of age.[293]

¶Estimate considered unreliable or does not meet standards of reliability or precision.

Sources: Prevalence: National Health and Nutrition Examination Survey 2009 to 2012, National Center for Health Statistics (NCHS) and National Heart, Lung, and Blood Institute (NHLBI). Percentages for racial/ethnic groups are age adjusted for Americans ≥20 years of age. Age-specific percentages are extrapolated to the 2012 US population. Incidence: Greater Cincinnati/Northern Kentucky Stroke Study/National Institutes of Neurological Disorders and Stroke data for 1999 provided on August 1, 2007. US estimates compiled by NHLBI. See also Kissela et al.[294] Data include children. Mortality: Centers for Disease Control and Prevention/NCHS, 2013 Mortality Multiple Cause-of-Death–United States. These data represent underlying cause of death only. Hospital discharges: National Hospital Discharge Survey, NCHS. Data include those inpatients discharged alive, dead, or status unknown. Cost: NHLBI. Data include estimated direct and indirect costs for 2011 to 2012 (average annual).

Table 14-2. Modifiable Stroke Risk Factors

Factor	Prevalence, %	PAR, %*	RR
Cigarette smoking			
Overall	19.8	12–14†	1.9
Men	22.3		
Women	17.4		
Hypertension		‡	8
Ages 20–34 y			
Men	13.4	99	
Women	6.2	98	
Ages 35–44 y			
Men	23.2	99	
Women	16.5	106	
Ages 45–54 y			
Men	36.2	100	
Women	35.9	103	
Ages 55–64 y			
Men	53.7	100	
Women	55.8	102	
Ages 65–74 y			
Men	64.7	100	
Women	69.6	101	
Ages ≥75 y			
Men	64.1	100	
Women	76.4	101	
Diabetes mellitus	7.3	5–27	1.8–6.0
High total cholesterol	Data calculated for highest quintile (20%) vs lowest quintile	9.1 (5.7–13.8)	1.5 (95% CI, 1.3–1.8)
	Continuous risk for ischemic stroke	…	1.25 per 1-mmol/L (38.7 mg/dL) increase
Low HDL-C			
<40 mg/dL			
Men	35		
Women	15		
	Data calculated for highest quintile (20%) vs lowest quintile	23.7	0.4
<35 mg/dL	26	20.6 (10.1–30.7)	2.00 (95% CI, 1.43–2.70)
	Continuous risk for ischemic stroke		≈0.5–0.6 for each 1-mmol/L increase
AF (nonvalvular)			
Overall age, y			
50–59	0.5	1.5	4.0
60–69	1.8	2.8	2.6
70–79	4.8	9.9	3.3
80–89	8.8	23.5	4.5
Asymptomatic carotid stenosis	2–8	2–7§	2.0
Sickle cell disease	0.25 (of blacks)	…	200–400‖
Postmenopausal hormone therapy	25 (Women 50–74 y of age)	9	1.4
Oral contraceptive use	13 (women 25–44 y)	9.4	2.3
Dietary factors			
Na intake >2300 mg	75–90	Unknown	Unknown
K intake <4700 mg	90–99	Unknown	Unknown

(*Continued*)

Table 14-2. Continued

Factor	Prevalence, %	PAR, %*	RR
Physical inactivity	25	30	2.7
Obesity			1.39 Stroke death per increase of 5 kg/m^2
Men	33.3		
Women	35.3		
CHD			
Men	8.4	5.8	1.73 (1.68–1.78)
Women	5.6	3.9¶	1.55 (1.17–2.07)
Heart failure			
Men	2.6	1.4	
Women	2.1	1.1¶	
Peripheral arterial disease	4.9	3.0¶	

AF indicates atrial fibrillation; CHD, coronary heart disease; CI, confidence interval; HDL-C, high-density lipoprotein cholesterol; PAR, population attributable risk; and RR, relative risk.

*PAR is the proportion of ischemic stroke in the population that can be attributed to a particular risk factor (see Goldstein et al[104] for formula).

†PAR is for stroke deaths, not ischemic stroke incidence.

‡PAR percent=100×{[prevalence (RR−1)/prevalence (RR−1)+1]}.

§Calculated on the basis of referenced data provided in the table or text.

‖Relative to stroke risk in children without sickle cell disease.

¶Calculated on the basis of point estimates of referenced data provided in the table. For peripheral arterial disease, calculation was based on average RR for men and women.

Adapted from Goldstein et al[104] with permission. Copyright © 2011, American Heart Association, Inc.

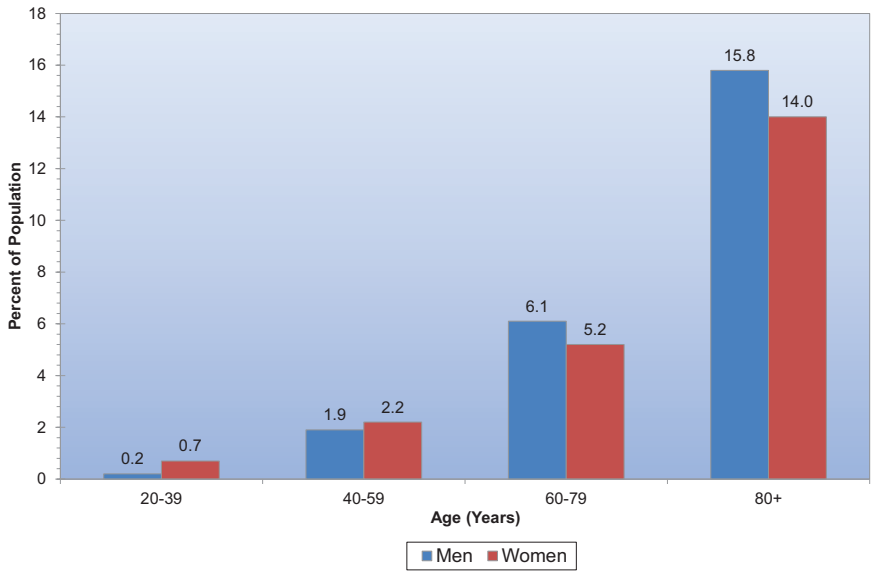


Chart 14-1. Prevalence of stroke by age and sex (National Health and Nutrition Examination Survey: 2009–2012). Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

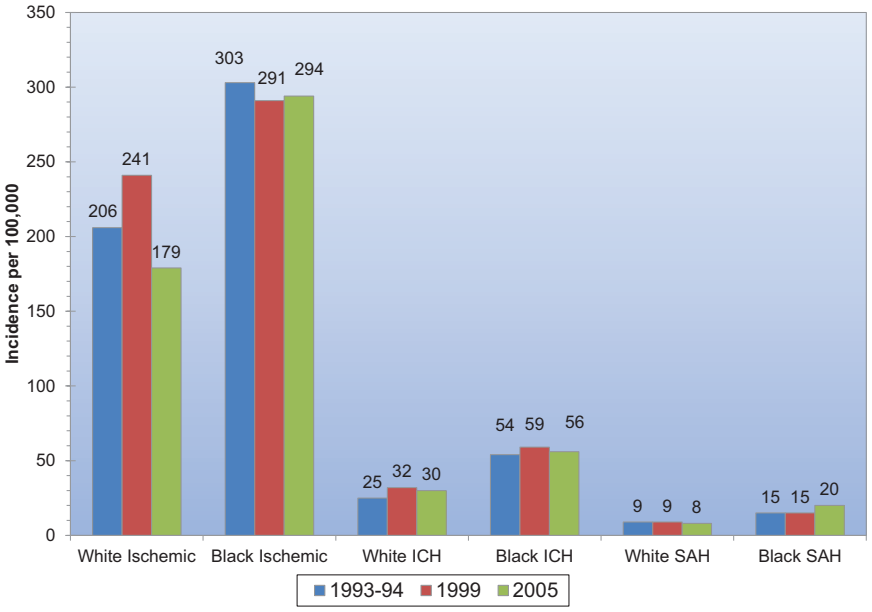


Chart 14-2. Annual age-adjusted incidence of first-ever stroke by race. Hospital plus out-of-hospital ascertainment, 1993 to 1994, 1999, and 2005. ICH indicates intracerebral hemorrhage; and SAH, subarachnoid hemorrhage. Data derived from Kleindorfer et al.[14]

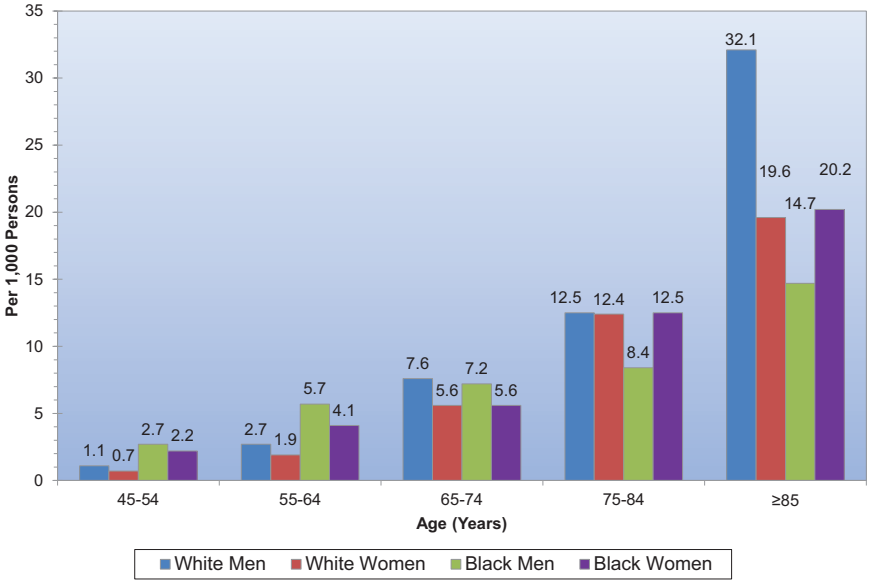


Chart 14-3. Annual rate of first cerebral infarction by age, sex, and race (Greater Cincinnati/Northern Kentucky Stroke Study: 1999). Rates for black men and women 45 to 54 years of age and for black men ≥75 years of age are considered unreliable. Source: Unpublished data from the Greater Cincinnati/Northern Kentucky Stroke Study.

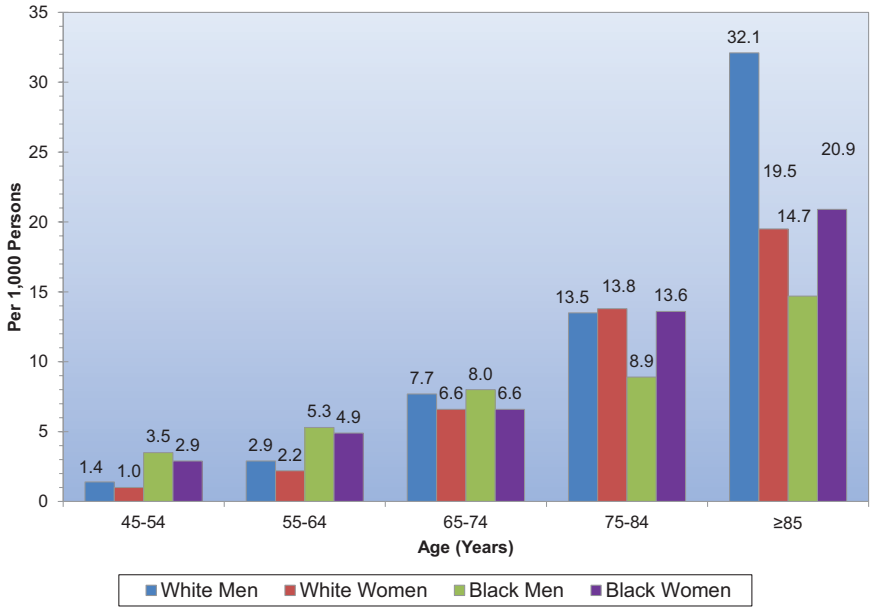


Chart 14-4. Annual rate of all first-ever strokes by age, sex, and race (Greater Cincinnati/Northern Kentucky Stroke Study: 1999). Rates for black men and women 45 to 54 years of age and for black men ≥75 years of age are considered unreliable.

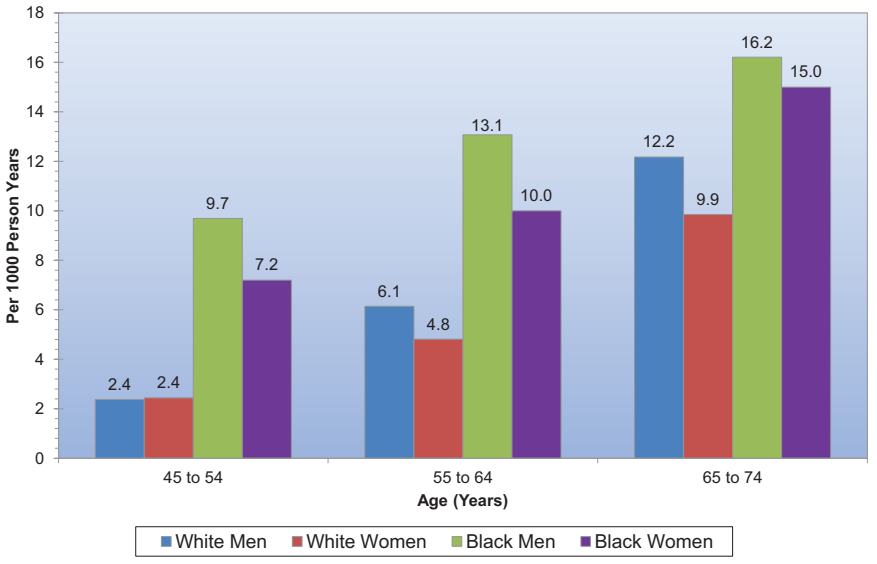


Chart 14-5. Age-adjusted incidence of stroke/transient ischemic attack by race and sex, ages 45 to 74 years, Atherosclerosis Risk in Communities study cohort, 1987 to 2001. Data derived from the National Heart, Lung, and Blood Institute's *2006 Chart Book on Cardiovascular and Lung Diseases*.[295]

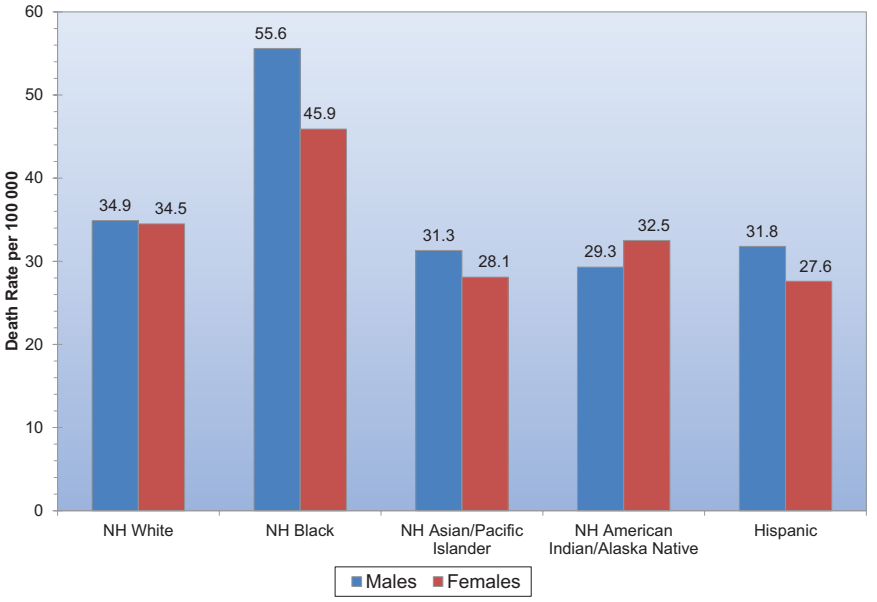


Chart 14-6. Age-adjusted death rates for stroke by sex and race/ethnicity, 2013. Death rates for the American Indian or Alaska Native and Asian or Pacific Islander populations are known to be underestimated. Stroke includes *International Classification of Diseases, 10th Revision* codes I60 through I69 (cerebrovascular disease). NH indicates non-Hispanic. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

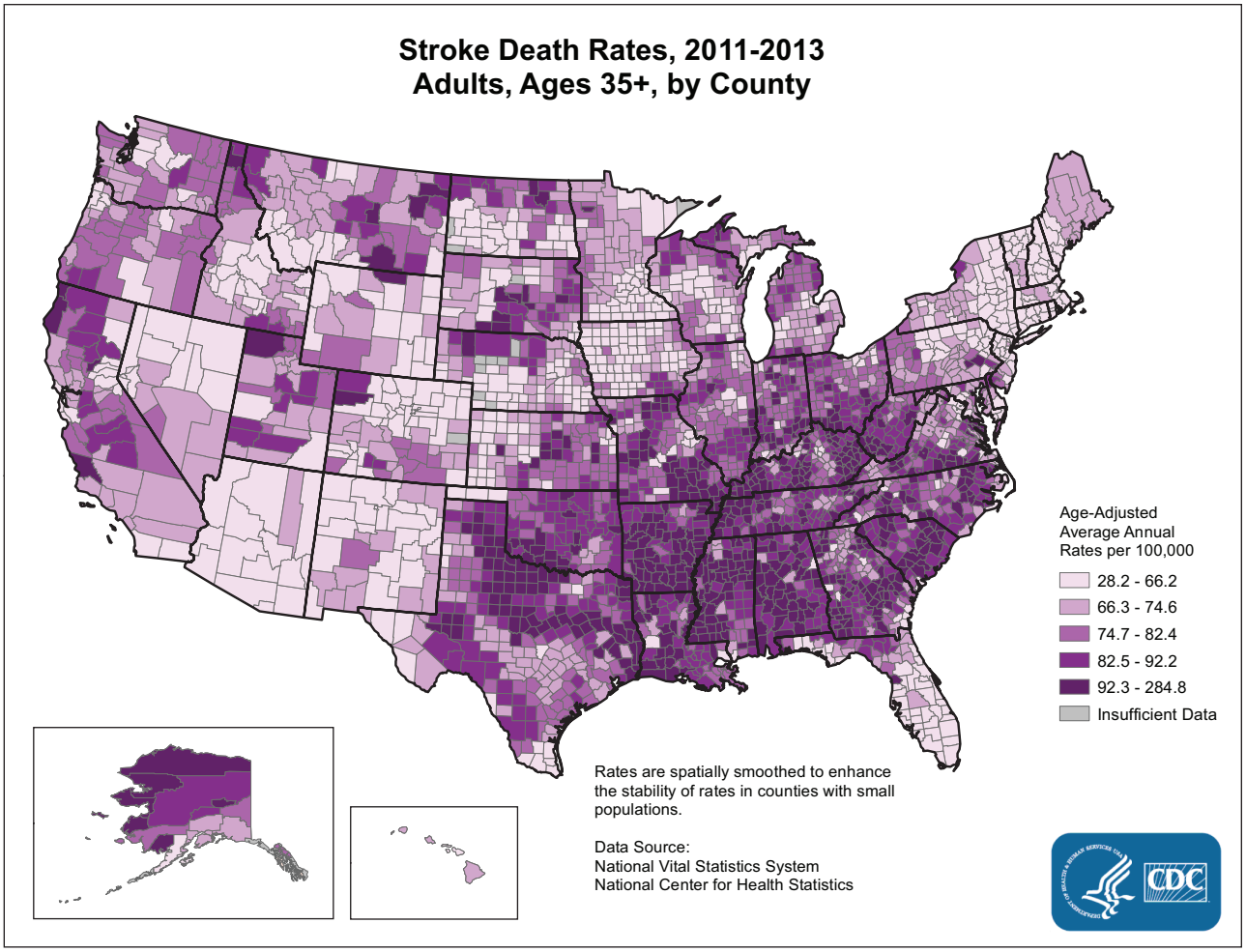
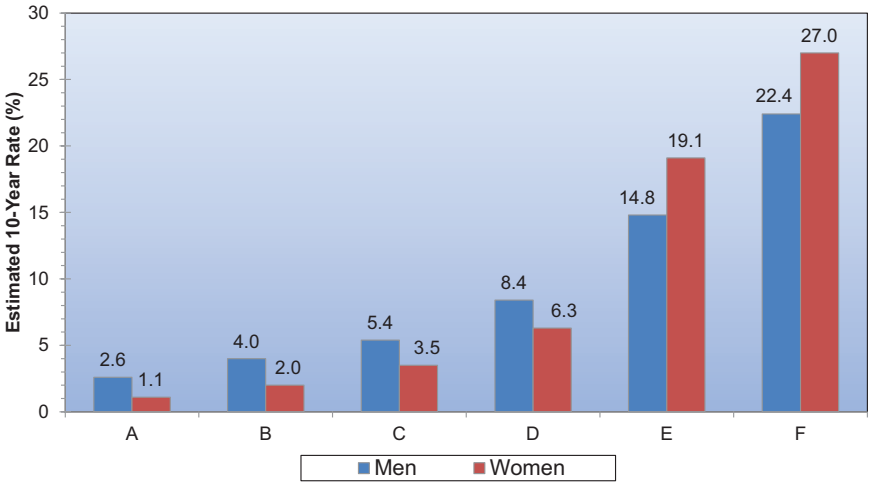


Chart 14-7. Stroke death rates, 2011 through 2013. Adults ≥35 years of age, by county. Rates are spatially smoothed to enhance the stability of rates in counties with small populations. *International Classification of Diseases, 10th Revision* codes for stroke: I60 through I69. Data source: National Vital Statistics System and National Center for Health Statistics.



	A	B	C	D	E	F
Blood Pressure*	95-105	138-148	138-148	138-148	138-148	138-148
Diabetes	No	No	Yes	Yes	Yes	Yes
Cigarette Smoking	No	No	No	Yes	Yes	Yes
Prior AF	No	No	No	No	Yes	Yes
Prior CVD	No	No	No	No	No	Yes

* - Closest ranges for women are : 95-104 and 115-124.

Chart 14-8. Estimated 10-year stroke risk in adults 55 years of age according to levels of various risk factors (Framingham Heart Study). AF indicates atrial fibrillation; and CVD, cardiovascular disease. Data derived from Wolf et al[296] with permission. Copyright © 1991, American Heart Association.

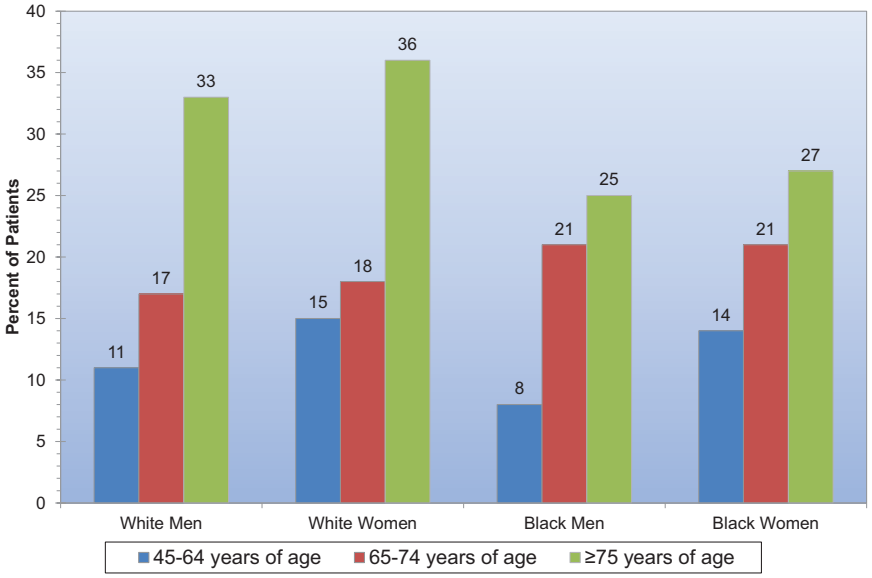


Chart 14-9. Probability of death within 1 year after first stroke. Source: Pooled data from the Framingham Heart Study, Atherosclerosis Risk in Communities Study, Cardiovascular Health Study, Multi-Ethnic Study of Atherosclerosis, Coronary Artery Risk Development in Young Adults, and Jackson Heart Study of the National Heart, Lung, and Blood Institute.

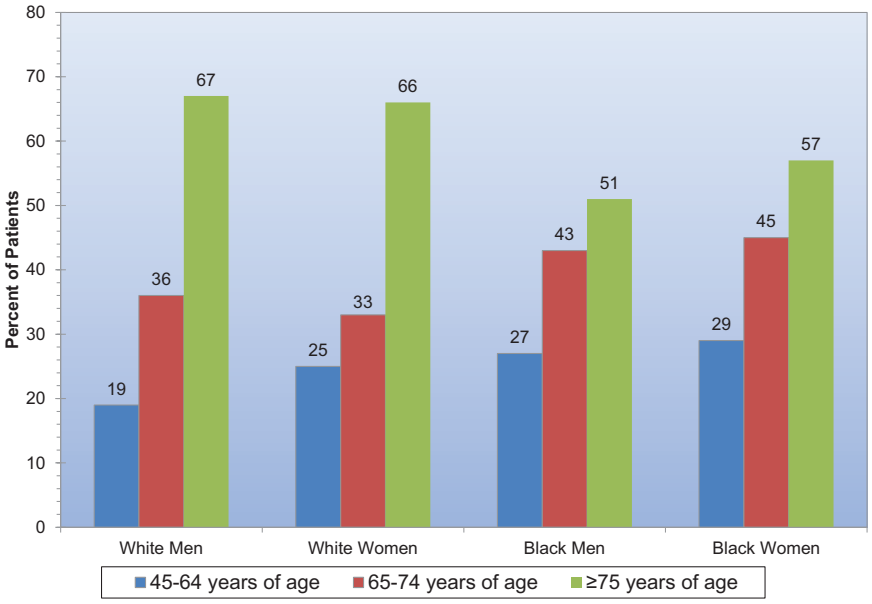


Chart 14-10. Probability of death within 5 years after first stroke. Source: Pooled data from the Framingham Heart Study, Atherosclerosis Risk in Communities Study, Cardiovascular Health Study, Multi-Ethnic Study of Atherosclerosis, Coronary Artery Risk Development in Young Adults, and Jackson Heart Study of the National Heart, Lung, and Blood Institute.

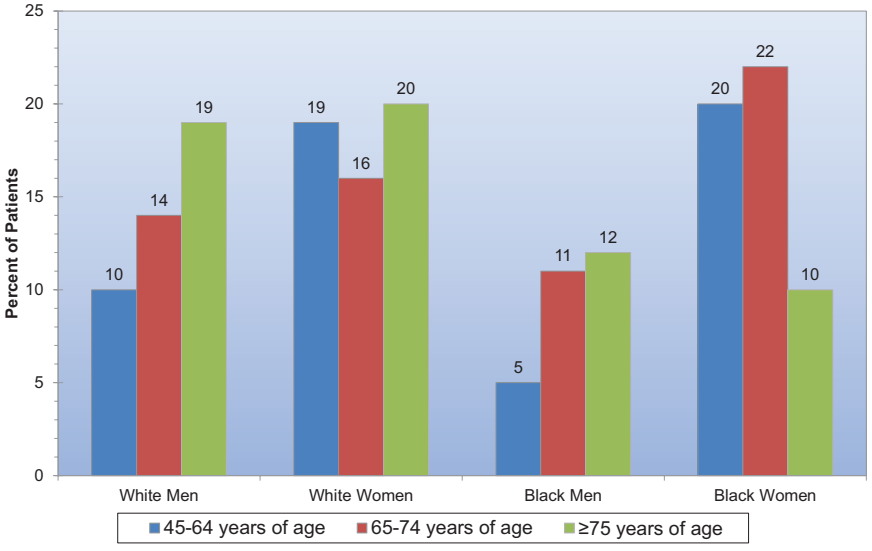


Chart 14-11. Probability of death with recurrent stroke in 5 years after first stroke. Source: Pooled data from the Framingham Heart Study, Atherosclerosis Risk in Communities Study, Cardiovascular Health Study, Multi-Ethnic Study of Atherosclerosis, Coronary Artery Risk Development in Young Adults, and Jackson Heart Study of the National Heart, Lung, and Blood Institute.

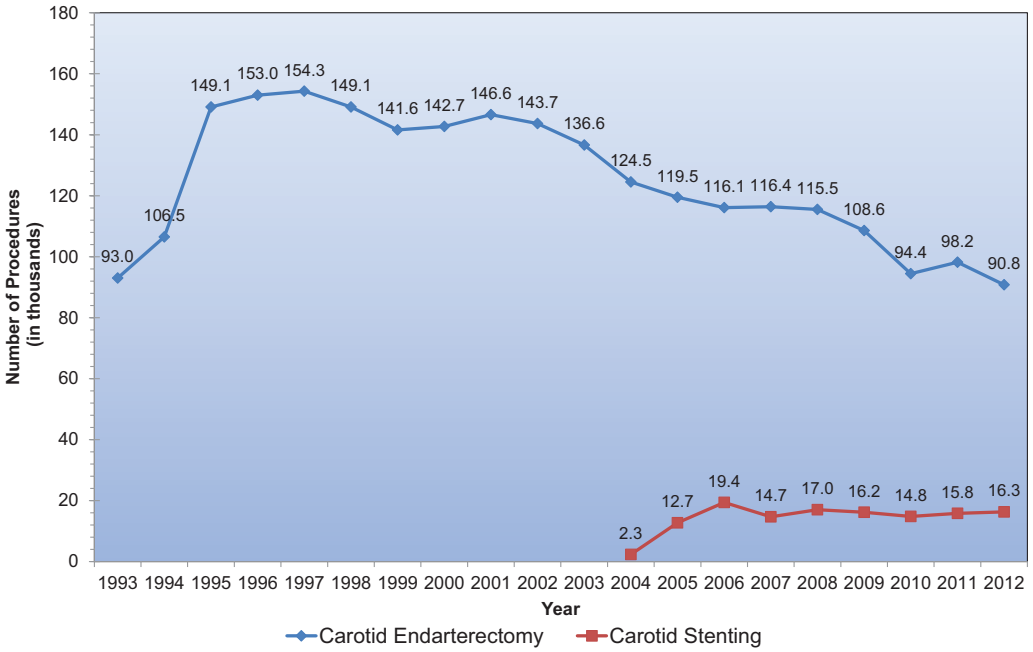


Chart 14-12. Trends in carotid endarterectomy and carotid stenting procedures (United States: 1993–2012). Source: Nationwide Inpatient Sample, Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality.

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15. Congenital Cardiovascular Defects and Kawasaki Disease

ICD-9 745 to 747, ICD-10 Q20 to Q28. See Tables 15-1 through 15-4 and Charts 15-1 through 15-5.

Congenital cardiovascular defects, also known as congenital heart defects, are structural problems that arise from abnormal formation of the heart or major blood vessels. *ICD-9* lists 25 congenital heart defect codes, of which 21 designate specific anatomic or hemodynamic lesions; however, there are many more lesions that are not well described by *ICD-9* or *ICD-10* codes because of the wide diversity of congenital heart malformations. Defects range in severity from tiny pinholes between chambers that may resolve spontaneously to major malformations that can require multiple surgical procedures before school age and may result in death in utero, in infancy, or in childhood. As such, congenital heart defects are serious and common conditions that have a significant impact on morbidity, mortality, and healthcare costs in children and in adults.[1] Some types of congenital heart defects are associated with diminished quality of life,[2] on par with what is seen in other chronic pediatric health conditions,[3] and deficits in cognitive functioning[4] and neurodevelopmental outcomes.[5] Health outcomes are improving for congenital cardiovascular defects and survival is increasing, leading to a population shift toward adulthood, which means there are many more adults with both congenital HD and adult medical diagnoses,[6] adding to the complexity of their management[7,8] and emphasizing the need for coordinated care by an adult congenital heart defects specialist.[9]

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Abbreviations Used in Chapter 15

AHA	American Heart Association
ASD	atrial septal defect
AV	atrioventricular
CABG	coronary artery bypass graft
CDC	Centers for Disease Control and Prevention
CI	confidence interval
DM	diabetes mellitus
HCUP	Healthcare Cost and Utilization Project
HD	heart disease
HLHS	hypoplastic left heart syndrome
ICD-9	*International Classification of Diseases, 9th Revision*
ICD-10	*International Classification of Diseases, 10th Revision*
KD	Kawasaki disease
NCHS	National Center for Health Statistics
NH	non-Hispanic
NHLBI	National Heart, Lung, and Blood Institute
OR	odds ratio
RR	relative risk
STS	Society of Thoracic Surgeons
TGA	transposition of the great arteries
TOF	tetralogy of Fallot
VSD	ventricular septal defect

Incidence

The incidence of congenital heart defects in the United States is commonly reported as being between 4 and 10 per 1000, clustering around 8 per 1000 live births.[10] Incidence (birth prevalence) in Europe is reported as 6.9 per 1000 births; birth prevalence in Asia is reported as 9.3 per 1000.[11] Variations in incidence rates may be related to the age at detection; major defects may be apparent in the prenatal or neonatal period, but minor defects may not be detected until adulthood, which makes it challenging to estimate incidence and prevalence. To distinguish more serious defects, some studies report the number of new cases of sufficient severity to result in death or an invasive procedure within the first year of life, in addition to overall birth prevalence. Incidence rates are likely to increase over time because of better detection by fetal cardiac ultrasound,[12] screening pulse oximetry,[13] and echocardiography during infancy.

Overall Incidence

(See Table 15-2.)

- Population-based data from the Metropolitan Atlanta Congenital Defects Program (Atlanta, GA): Congenital heart defects occurred in 1 of every 111 to 125 births (live, still, or >20 weeks' gestation) from 1995 to 1997 and from 1998 to 2005. Some defects showed variations by sex and racial distribution.[14]
- Population-based data from Alberta, Canada: Total prevalence of 12.42 per 1000 total births (live, still, or >20 weeks' gestation).[15]
- An estimated minimum of 40 000 infants are expected to be affected by congenital heart defects each year in the United States. Of these, ≈25%, or 2.4 per 1000 live births, require invasive treatment in the first year of life.[16]

Incidence of Specific Defects

- The National Birth Defects Prevention Network for 13 states in the United States from 2004 to 2006 showed the average prevalence of 21 selected major birth defects. These data indicated that there are >6100 estimated annual cases of 5 cardiovascular defects: truncus arteriosus (0.07/1000 births), TGA (0.3/1000 births), TOF (0.4/1000 births), AV septal defect (0.47/1000 births), and HLHS (0.23/1000 births).[17]
- Metropolitan Atlanta Congenital Defects Program data for specific defects at birth: VSD, 4.2/1000 births; ASD, 1.3/1000 births; valvar pulmonic stenosis, 0.6/1000 births; TOF, 0.5/1000 births; aortic coarctation, 0.4/1000 births; AV septal defect, 0.4/1000 births; and TGA (0.2/1000 births).[14,18]
- Bicuspid aortic valve occurs in 13.7 per 1000 people; these defects may not require treatment in infancy but can cause problems later in adulthood.[19]

Prevalence

(See Tables 15-1 through 15-3.)

The population with congenital HD has grown substantially over the past several decades, which is related to better surgical outcomes and improved medical management;

this has led to an aging of the congenital HD population.[20] The 32nd Bethesda Conference estimated that the total number of adults living with congenital HD in the United States in 2000 was 800 000.[1,21] In the United States, 1 in 150 adults are expected to have some form of congenital HD.[8] In population data from Canada, the measured prevalence of congenital heart defects in the general population was 11.89 per 1000 children and 4.09 per 1000 adults in the year 2000.[22] Extrapolated to the US population in the same year, this yields published estimates of 859 000 children and 850 000 adults for the year 2000.[18] The expected growth rates of the congenital heart defects population vary from 1% to 5% per year depending on age and the distribution of lesions.[19] Limited information is available about the prevalence of congenital heart defects outside the United States. The overall birth prevalence of congenital heart defects at the Bhabha Atomic Research Centre Hospital in Mumbai from 2006 through 2011 was 13.28 per 1000 live births.[23]

Estimates of the distribution of lesions in the congenital heart defects population using available data vary with assumptions made. If all those born with congenital heart defects between 1940 and 2002 were treated, there would be 750 000 survivors with simple lesions, 400 000 with moderate lesions, and 180 000 with complex lesions; in addition, there would be 3.0 million subjects alive with bicuspid aortic valves.[24] Without treatment, the number of survivors in each group would be 400 000, 220 000, and 30 000, respectively. The actual numbers surviving were projected to be between these 2 sets of estimates as of 1 decade ago.[24] According to measurements from population data in Canada, the prevalence of severe forms of congenital heart defects increased 85% in adults and 22% in children from 1985 to 2000.[22] The most common types of defects in children are VSD, 620 000 people; ASD, 235 000 people; valvar pulmonary stenosis, 185 000 people; and patent ductus arteriosus, 173 000 people.[24] The most common lesions seen in adults are ASD and TOF.[21]

Mortality

(See Tables 15-1 and 15-4 and Charts 15-1 through 15-5.)

- Overall mortality attributable to congenital heart defects:
  - —In 2013[25]:
    - Mortality related to congenital cardiovascular defects was 3051 deaths. Any-mention mortality related to congenital cardiovascular defects was 4916 deaths.
    - Congenital cardiovascular defects (*ICD-10* Q20–Q28) were the most common cause of infant deaths resulting from birth defects (*ICD-10* Q00–Q99); 24.0% of infants who died of a birth defect had a heart defect (*ICD-10* Q20-Q24).
    - The age-adjusted death rate (deaths per 100 000 people) attributable to congenital cardiovascular defects was 1.0.
  - —In population-based data from Canada, 8123 deaths occurred among 71 686 patients with congenital heart defects followed up for nearly 1 million patient-years.[8]
  - —In 2007, 189 000 life-years were lost before 55 years of age because of deaths attributable to congenital cardiovascular defects. This is almost as many life-years as were lost from leukemia and asthma combined (NHLBI tabulation of NCHS mortality data).
  - —Death rates attributed to congenital heart defects decrease as gestational age advances toward 40 weeks,[26] and similarly, in-hospital death of infants with major congenital heart defects is independently associated with late-preterm birth (OR, 2.70; 95% CI, 1.69–4.33) compared with delivery at later gestational ages.[27] The presence of congenital HD substantially increases mortality of very low-birth-weight infants; in a study of very low-birth-weight infants, the mortality rate with serious congenital HD was 44% compared with 12.7% in very low-birth-weight infants without serious congenital HD.[28]
- Congenital heart defect–related mortality varies substantially by age, with infants showing the highest mortality rates.
  - —Analysis of the STS Congenital Heart Surgery Database, a voluntary registry with self-reported data for a 4-year cycle (2011–2014) from 116 centers performing congenital heart defects surgery (112 based in 40 US states, 3 in Canada, and 1 in Turkey),[29] showed that of 97 996 total patients who underwent an operation, the aggregate hospital discharge mortality rate was 3.3%.[30] The mortality rate was 9.2% for neonates (0–30 days of age),[31] 2.9% for infants (31 days to 1 year of age),[32] 1.1% for children (>1 year to 18 years of age),[33] and 1.9% for adults (>18 years of age).[34]
- Congenital heart defect mortality varies by race/ethnicity and sex.
  - —The US 2013 age-adjusted death rate (deaths per 100 000 people) attributable to congenital cardiovascular defects was 1.1 for non-Hispanic white males, 1.3 for non-Hispanic black males, 0.9 for Hispanic males, 0.9 for non-Hispanic white females, 1.1 for non-Hispanic black females, and 0.8 for Hispanic females. Infant (<1 year of age) mortality rates were 30.8 for non-Hispanic white infants, 42.0 for non-Hispanic black infants, and 33.3 for Hispanic infants[25] (Chart 15-1).
  - —Mortality after congenital heart surgery also differs between races/ethnicity, even after adjustment for access to care. The risk of in-hospital mortality for minority patients compared with white patients is 1.22 (95% CI, 1.05–1.41) for Hispanics, 1.27 (95% CI, 1.09–1.47) for non-Hispanic blacks, and 1.56 (95% CI, 1.37–1.78) for other non-Hispanics.[35] Similarly, another study found that a higher risk of in-hospital mortality was associated with nonwhite race (OR, 1.36; 95% CI, 1.19–1.54), as well as Medicaid insurance (OR, 1.26; 95% CI, 1.09–1.46).[36] One center's experience suggested race was independently associated with neonatal surgical outcomes only in the patients with less complex congenital heart defects.[37]
  - —Data from HCUP's Kids' Inpatient Database from 2000, 2003, and 2006 show male children had more congenital heart defects surgeries in infancy, more high-risk surgeries, and more procedures to correct multiple cardiac defects. Female infants with high-risk congenital heart defects had a 39% higher adjusted mortality than males.[38] According to CDC multiple-cause death data from 1999 to 2006, sex differences in mortality over time varied with age. Between the ages of 18 and 34 years, mortality over time decreased significantly in females but not in males.[39]

- Congenital heart defect mortality is declining.
  - —In studies that examined trends since 1979, age-adjusted death rates declined 22% for critical congenital heart defects[40] and 39% for all congenital heart defects,[41] and deaths tended to occur at progressively older ages. CDC mortality data from 1979 to 2005 show all-age death rates have declined by 60% for VSD and 40% for TOF.[42] Population-based data from Canada show overall mortality decreased by 31% and the median age of death increased from 2 to 23 years between 1987 and 2005.[8]
  - —Further analysis of the Kids' Inpatient Database from 2000 to 2009 showed a decrease in HLHS stage 3 mortality by 14% and a decrease in stage 1 mortality by 6%.[43] Surgical interventions are the primary treatment for reducing mortality. A Pediatric Heart Network study of 15 North American centers revealed that even in lesions associated with the highest mortality, such as HLHS, aggressive palliation can lead to an increase in the 12-month survival rate, from 64% to 74%.[44] Surgical interventions are common in adults with congenital heart defects. Mortality rates for 12 congenital heart defect procedures were examined using data from 1988 to 2003 reported in the Nationwide Inpatient Sample. A total of 30 250 operations were identified, which yielded a national estimate of 152 277±7875 operations. Of these, 27% were performed in patients ≥18 years of age. The overall in-hospital mortality rate for adult patients with congenital heart defects was 4.71% (95% CI, 4.19%–5.23%), with a significant reduction in mortality observed when surgery was performed on such adult patients by pediatric versus nonpediatric heart surgeons (1.87% versus 4.84%; $P<0.0001$).[45]

Risk Factors

- Numerous intrinsic and extrinsic nongenetic risk factors contribute to congenital heart defects.[46]
- Intrinsic risk factors for congenital heart defects include various genetic syndromes. Twins are at higher risk for congenital heart defects[47]; one report from Kaiser Permanente data showed monochorionic twins were at particular risk (RR, 11.6; CI, 9.2–14.5).[48] Known risks generally focus on maternal exposures, but a study of paternal occupational exposure documented a higher incidence of congenital heart defects with paternal exposure to phthalates.[49]
- Other paternal exposures that increase risk for congenital heart defects include paternal anesthesia, which has been implicated in TOF (3.6%); sympathomimetic medication and coarctation of the aorta (5.8%); pesticides and VSDs (5.5%); and solvents and HLHS (4.6%).[50]
- Known maternal risks include maternal smoking[51] during the first trimester of pregnancy, which has also been associated with a ≥30% increased risk of the following lesions in the fetus: ASD, pulmonary valvar stenosis, truncus arteriosus, TGA,[52] and septal defects (particularly for heavy smokers [≥25 cigarettes daily]).[53]
- Exposure to secondhand smoke has also been implicated as a risk factor.[54]
- Maternal binge drinking[55] is also associated with an increased risk of congenital cardiac defects, and the combination of binge drinking and smoking may be particularly dangerous: Mothers who smoke and report any binge drinking in the 3 months before pregnancy are at an increased risk of giving birth to a child with congenital heart defects (adjusted OR, 12.65).[55]
- On the basis of a meta-analysis of 14 studies, after the exclusion of women with gestational DM, infants born to moderately and severely obese mothers, respectively, had 1.1 and 1.4 times greater risk of congenital heart defects than infants born to normal-weight mothers.[56–58] The risk of TOF was 1.9 times higher among infants born to mothers with severe obesity than among infants born to normal-weight mothers.[56]
- Gestational DM has also been associated with cardiac defects, both isolated and multiple.[59,60]
- Folate deficiency is a well-accepted risk for congenital defects, including congenital heart defects, and folic acid supplementation is recommended during pregnancy.[46]
- A US population-based case-control study showed an inverse relationship between folic acid use and the risk of TGA (Baltimore-Washington Infant Study, 1981–1989).[61]
- An observational study from Quebec, Canada, of 1.3 million births from 1990 to 2005 found a 6% per year reduction in severe congenital heart defects using a time-trend analysis before and after public health measures were instituted that mandated folic acid fortification of grain and flour products in Canada.[62]
- High altitude has also been described as a risk factor for congenital heart defects; Tibetan children living at 4200 to 4900 m had a higher prevalence of congenital heart defects (12.09 per 1000) than those living at lower altitudes of 3500 to 4100 m; patent ductus arteriosus and ASD contributed to the increased prevalence.[63]

Screening

Pulse oximetry screening for critical congenital HD, a group of defects that cause severe and life-threatening symptoms and require intervention within the first days or first year of life, was recommended by the US Department of Health and Human Services on October 15, 2010,[64] was incorporated as part of the US recommended uniform screening panel for newborns in 2011, and has been endorsed by the AHA and the American Academy of Pediatrics.[65] The recommendation has been controversial, yet several studies demonstrate benefit.[66–68]

- Several key factors contribute to effective screening, including probe placement (postductal), oximetry cutoff (<95%), timing (>24 hours of life), and altitude (<2643 ft, 806 m).
- If fully implemented, screening would identify 1189 additional infants with critical congenital heart defects and would result in 1975 false-positive results.[69]
- It has been estimated that 29.5% (95% CI 28.1%–31.0%) of nonsyndromic children with congenital HD are diagnosed after 3 days and thus might benefit from pulse oximetry screening.[70]
- A meta-analysis of 13 studies that included 229 421 newborns found pulse oximetry had a sensitivity of 76.5% (95% CI, 67.7%–83.5%) for detection of critical congenital heart defects and a specificity of 99.9% (95% CI, 99.7%–99.9%) with a false-positive rate of 0.14% (95% CI, 0.06%–0.33%).[71]

- The cost of identifying a newborn with critical congenital heart defects has been estimated at $20 862 per newborn detected and $40 385 per life-year gained (2011 US dollars).

Hospitalizations

(See Table 15-1.)

- In 2004, birth defects accounted for >139 000 hospitalizations, representing 47.4 stays per 100 000 people. Cardiac and circulatory congenital anomalies accounted for 34% of all hospital stays for birth defects. Between 1997 and 2004, hospitalization rates increased by 28.5% for cardiac and circulatory congenital anomalies.[72]
- Although the most common congenital heart defect lesions were shunts, including patent ductus arteriosus, VSDs, and ASDs, TOF accounted for a higher proportion of in-hospital death than any other birth defect.

Cost

- Among pediatric hospitalizations (age 0–20 years) in the HCUP 2009 Kids' Inpatient Database[73]:
  - —Pediatric hospitalizations with congenital heart defects (3.7% of total pediatric hospitalizations) accounted for ≈$5.6 billion (15.1% of total pediatric hospitalization costs).
  - —26.7% of all congenital heart defect costs were attributed to critical congenital heart defects, with the highest costs attributable to HLHS, coarctation of the aorta, and TOF.
  - —Mean cost of congenital heart defects was higher in infancy ($36 601) than in older ages and in those with critical congenital heart defects ($52 899).
- Other studies confirm the high cost of HLHS. An analysis of 1941 neonates with HLHS showed a median cost of $99 070 for stage 1 palliation (Norwood or Sano procedure), $35 674 for stage 2 palliation (Glenn procedure), $36 928 for stage 3 palliation (Fontan procedure), and $289 292 for transplantation.[74]
- Other congenital heart defect lesions are less costly. In 2124 patients undergoing congenital heart operations between 2001 and 2007, total costs for the surgeries were $12 761 (ASD repair), $18 834 (VSD repair), $28 223 (TOF repair), and $55 430 (arterial switch operation).[75]

Kawasaki Disease

ICD-9 446.1; ICD-1 0 M30.3.

Mortality—5. Any-mention mortality—7.

- KD is an acute inflammatory illness characterized by fever, rash, nonexudative limbal sparing conjunctivitis, extremity changes, red lips and strawberry tongue, and a swollen lymph node. The most feared consequence of this vasculitis is coronary artery aneurysms.[76] The cause of KD is unknown, but it may be an immune response to an acute infectious illness based in part on genetic susceptibilities.[77,78] This is supported by variation in incidence related to geography, race/ethnicity, sex, age, and season.[79]
- The incidence of KD is highest in Japan, at 239.6 cases per 100 000 children aged <4 years,[80] followed by Taiwan at 164.6/100 000 in children <5 years old[81] and Korea, where the rate reached 113.1/100 000 children <5 years old in 2008.[82] KD is much less common in the United States, with an incidence of 20.8/100 000 children aged <5 years in 2006. The incidence of KD is rising worldwide, including in the United States. US hospitalizations for KD rose from 17.5/100 000 children aged <5 years in 2000 to 19/100 000 children <5 years of age in 2009.[83,84] Japan experienced its highest-ever incidence rate in 2010.[80] In addition to geographic variation in the incidence of KD, the age of children affected may also differ. In northern Europe (Finland, Sweden, and Norway), 67.8% of patients with KD were <5 years of age, compared with 86.4% of patients in Japan (P<0.001).[85]
- Race-specific incidence rates indicate that KD is most common among Americans of Asian and Pacific Island descent (30.3/100 000 children <5 years of age), occurs with intermediate frequency in non-Hispanic blacks (17.5/100 000 children <5 years of age) and Hispanics (15.7/100 000 children <5 years of age), and is least common in whites (12.0/100 000 children <5 years of age).[86] US states with higher Asian American populations have higher rates of KD; for example, rates are 2.5-fold higher in Hawaii than in the continental United States.[84]
- Boys have a 1.5-fold higher incidence of KD than girls.[84] Although KD can be seen as late as adolescence, 76.8% of children with KD are <5 years of age.[83,84,86] There are seasonal variations in KD: KD is more common during the winter and early spring months, except in Hawaii, where no clear seasonal trend is seen.[87]
- Treatment of KD rests on diminishing the inflammatory response with intravenous immunoglobulin infusion, which reduces the incidence of coronary artery aneurysms from ≈25% to ≈2%. Addition of prednisolone to the standard regimen of intravenous immunoglobulin for patients with severe KD appears to result in further reductions in the incidence of coronary artery anomalies (RR, 0.20; 95% CI, 0.12–0.28),[88] a result supported by a meta-analysis of steroid treatment in 9 trials that included 1011 patients with KD.[89] Successful surgical treatment (eg, CABG) of late sequelae of symptomatic coronary artery stenoses has been described.[90]

Table 15-1. Congenital Cardiovascular Defects

Population Group	Estimated Prevalence, 2002, All Ages	Mortality, 2013, All Ages*	Hospital Discharges, 2010, All Ages
Both sexes	650 000 to 1.3 million[24]	3051	62 000
Males	…	1634 (53.6%)†	38 000
Females	…	1417 (46.4%)†	24 000
NH white males	…	973	…
NH white females	…	869	…
NH black males	…	268	…
NH black females	…	234	…
Hispanic males		299	
Hispanic females		253	
NH Asian or Pacific Islander	…	119	…
NH American Indian or Alaska Native	…	30	…

Ellipses (…) indicate data not available. NH indicates non-Hispanic.

*Mortality for Hispanic, NH American Indian or Alaska Native, and NH Asian and Pacific Islander people should be interpreted with caution because of inconsistencies in reporting Hispanic origin or race on the death certificate compared with censuses, surveys, and birth certificates. Studies have shown underreporting on death certificates of American Indian or Alaska Native, Asian and Pacific Islander, and Hispanic decedents, as well as undercounts of these groups in censuses.

†These percentages represent the portion of total congenital cardiovascular mortality that is for males vs females.

Sources: Mortality: Centers for Disease Control and Prevention/National Center for Health Statistics, 2013 Mortality Multiple Cause-of-Death—United States. These data represent underlying cause of death only. Hospital discharges: National Hospital Discharge Survey, National Center for Health Statistics; data include those inpatients discharged alive, dead, or status unknown.

Table 15-2. Annual Birth Prevalence of Congenital Cardiovascular Defects in the United States[13,16,19,91–93]

Type of Presentation	Rate per 1000 Live Births	Estimated Number (Variable With Yearly Birth Rate)
Fetal loss	Unknown	Unknown
Invasive procedure during the first year	2.4	9200
Detected during first year*	8	36 000
Bicuspid aortic valve	13.7	54 800

*Includes stillbirths and pregnancy termination at <20 weeks' gestation; includes some defects that resolve spontaneously or do not require treatment.

Table 15-3. Estimated Prevalence of Congenital Cardiovascular Defects and Percent Distribution by Type, United States, 2002* (in Thousands)

	Prevalence, n			Percent of Total		
Type	Total	Children	Adults	Total	Children	Adults
Total	994	463	526	100	100	100
VSD†	199	93	106	20.1	20.1	20.1
ASD	187	78	109	18.8	16.8	20.6
Patent ductus arteriosus	144	58	86	14.2	12.4	16.3
Valvular pulmonic stenosis	134	58	76	13.5	12.6	14.4
Coarctation of aorta	76	31	44	7.6	6.8	8.4
Valvular aortic stenosis	54	25	28	5.4	5.5	5.2
TOF	61	32	28	6.1	7	5.4
AV septal defect	31	18	13	3.1	3.9	2.5
TGA	26	17	9	2.6	3.6	1.8
Hypoplastic right heart syndrome	22	12	10	2.2	2.5	1.9
Double-outlet right ventricle	9	9	0	0.9	1.9	0.1
Single ventricle	8	6	2	0.8	1.4	0.3
Anomalous pulmonary venous connection	9	5	3	0.9	1.2	0.6
Truncus arteriosus	9	6	2	0.7	1.3	0.5
HLHS	3	3	0	0.3	0.7	0
Other	22	12	10	2.1	2.6	1.9

Average of the low and high estimates, two thirds from low estimate.[24]ASD indicates atrial septal defect; AV, atrioventricular; HLHS, hypoplastic left heart syndrome; TGA, transposition of the great arteries; TOF, tetralogy of Fallot; and VSD, ventricular septal defect.

*Excludes an estimated 3 million bicuspid aortic valve prevalence (2 million in adults and 1 million in children).

†Small VSD, 117 000 (65 000 adults and 52 000 children); large VSD, 82 000 (41 000 adults and 41 000 children).

Source: Data derived from Hoffman et al.[24]

Table 15-4. Surgery for Congenital Heart Disease

	Sample	Population, Weighted
Surgery for congenital heart disease, n	14 888	25 831
Deaths, n	736	1253
Mortality rate, %	4.9	4.8
By sex (81 missing in sample)		
Male, n	8127	14 109
Deaths, n	420	714
Mortality rate, %	5.2	5.1
Female, n	6680	11 592
Deaths, n	315	539
Mortality rate, %	4.7	4.6
By type of surgery		
ASD secundum surgery, n	834	1448
Deaths, n	3	6
Mortality rate, %	0.4	0.4
Norwood procedure for HLHS, n	161	286
Deaths, n	42	72
Mortality rate, %	26.1	25.2

In 2003, 25 000 cardiovascular operations for congenital cardiovascular defects were performed on children <20 years of age. Inpatient mortality rate after all types of cardiac surgery was 4.8%. Nevertheless, mortality risk varies substantially for different defect types, from 0.4% for ASD repair to 25.2% for first-stage palliation for HLHS. Fifty-five percent of operations were performed in males. In unadjusted analysis, mortality after cardiac surgery was somewhat higher for males than for females (5.1% vs 4.6%). ASD indicates atrial septal defect; and HLHS, hypoplastic left heart syndrome.

Source: Data derived from Ma et al.[94]

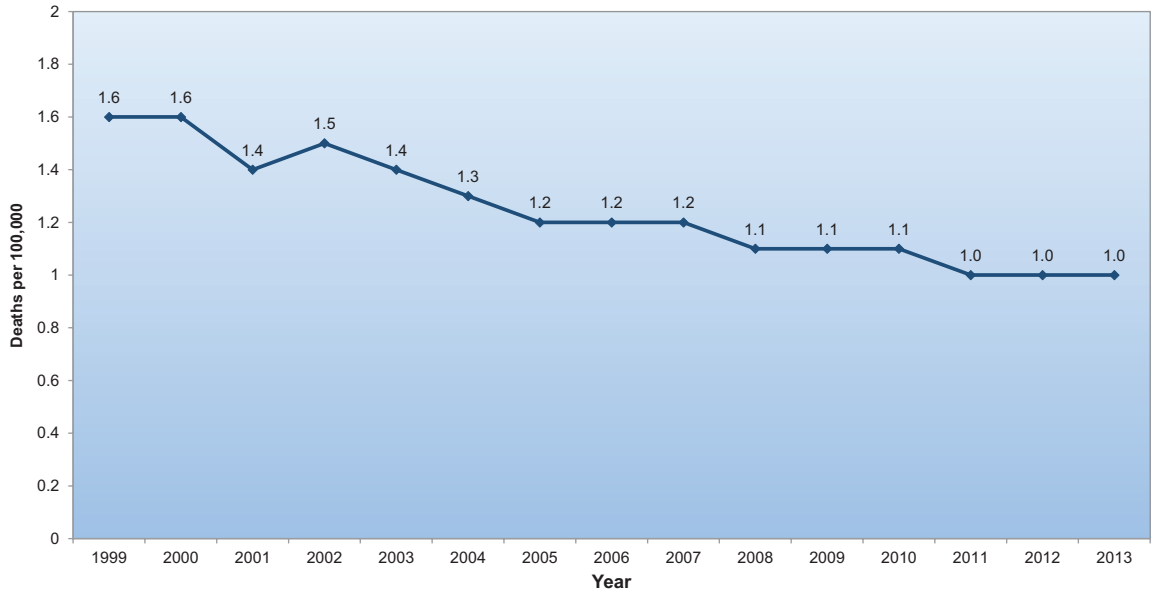

Chart 15-1. Trends in age-adjusted death rates attributable to congenital heart defects, 1999 to 2013. Source: National Center for Health Statistics.

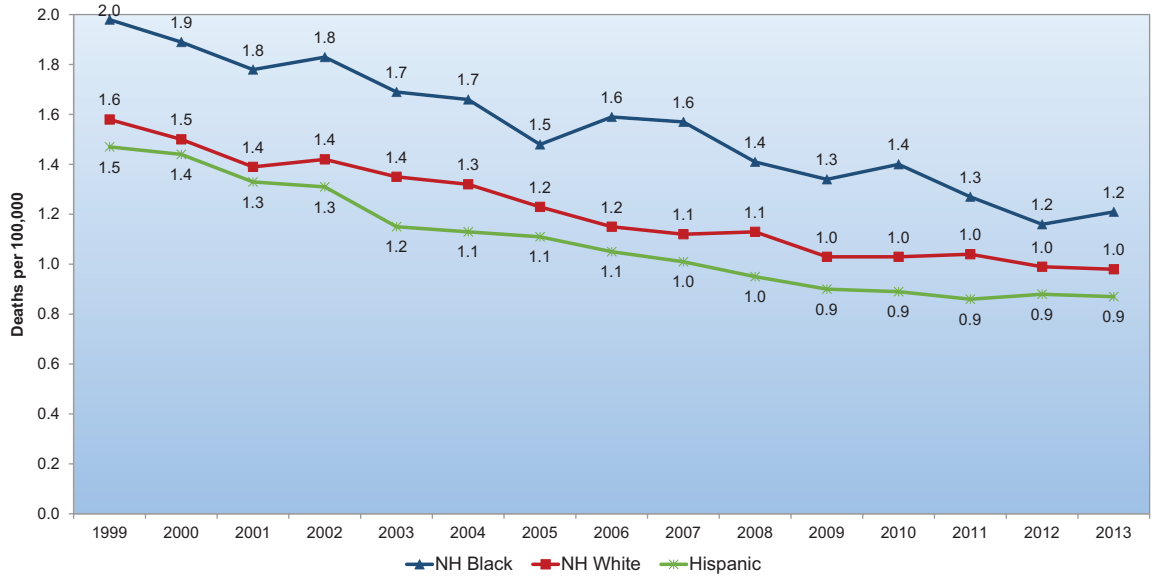

Chart 15-2. Trends in age-adjusted death rates attributable to congenital heart defects by race/ethnicity, 1999 to 2013. NH indicates non-Hispanic. Source: National Center for Health Statistics.

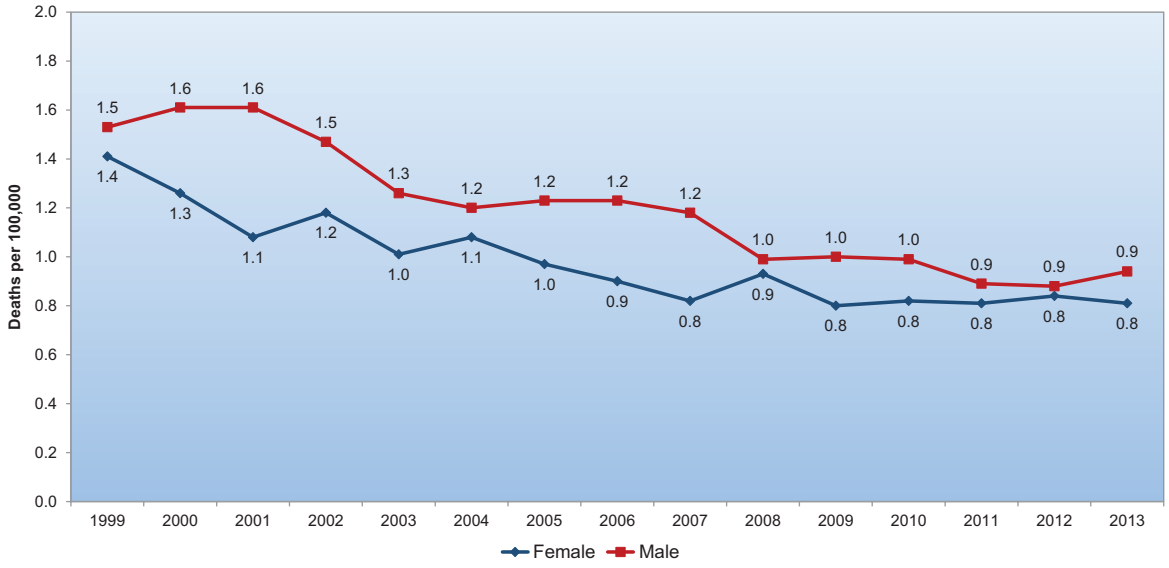

Chart 15-3. Trends in age-adjusted death rates attributable to congenital heart defects by sex, 1999 to 2013. Source: National Center for Health Statistics.

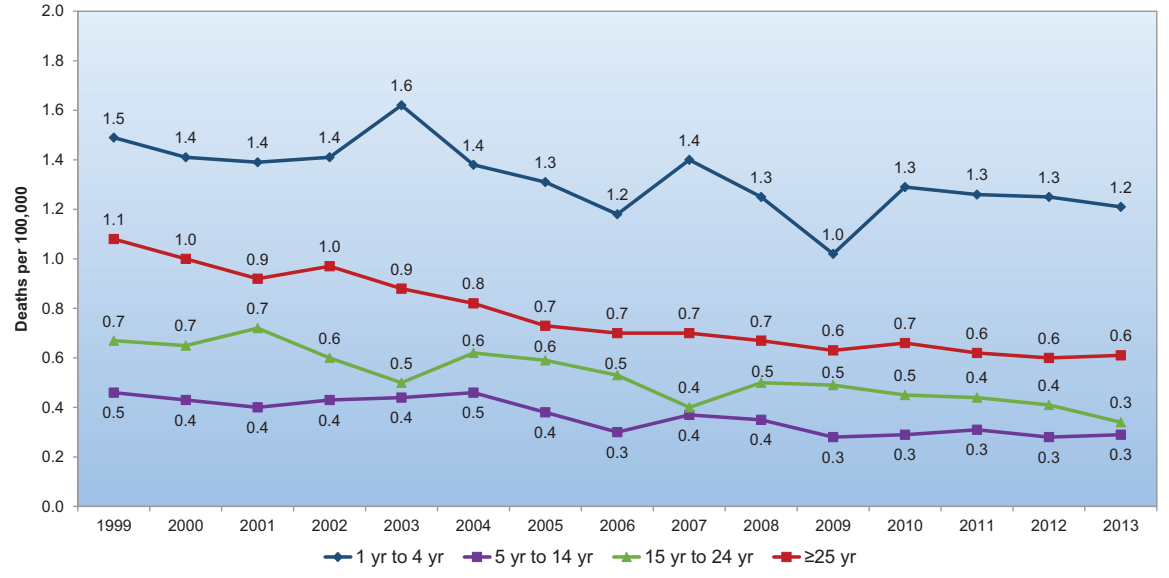

Chart 15-4. Trends in age-adjusted death rates attributable to congenital heart defects by age at death, 1999 to 2013. Source: National Center for Health Statistics.

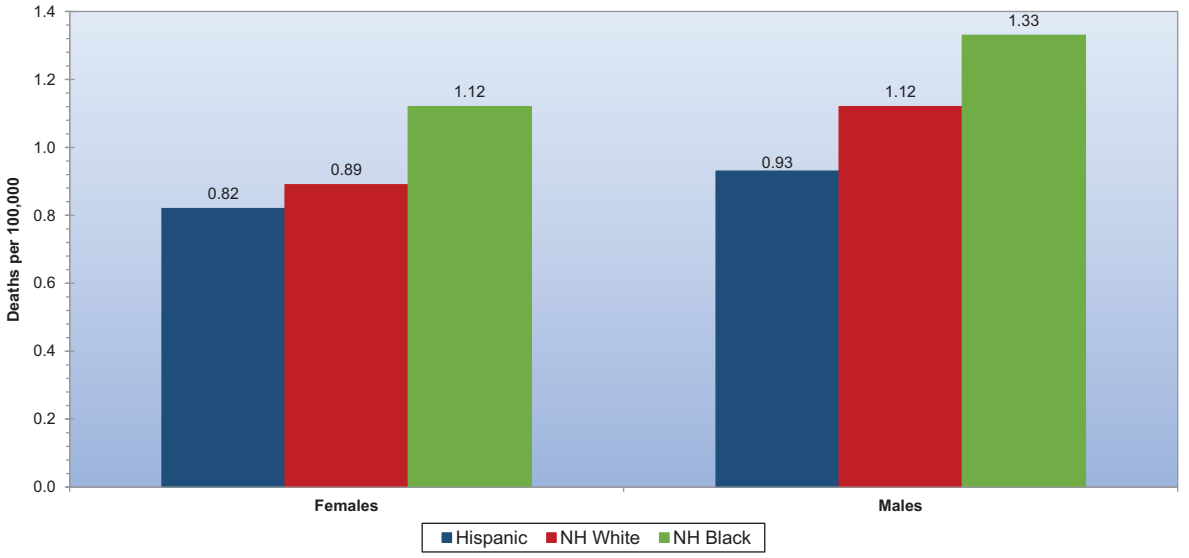

Chart 15-5. Trends in age-adjusted death rates attributable to congenital heart defects by sex and race/ethnicity, 1999 to 2013. NH indicates non-Hispanic. Source: National Center for Health Statistics.

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16. Disorders of Heart Rhythm

See Table 16-1 and Charts 16-1 through 16-10.

Bradyarrhythmias

ICD-9 426.0, 426.1, 427.81; ICD-10 I44.0 to I44.3, I49.5.

Mortality—994. Any-mention mortality—5383. Hospital discharges—110 000.

AV Block

Prevalence and Incidence

(See Chart 16-1.)

- In a healthy sample of participants from the ARIC study (mean age 53 years), the prevalence of first-degree AV block was 7.8% in black men, 3.0% in black women, 2.1% in white men, and 1.3% in white women.[1] Lower prevalence estimates were noted in the relatively younger population (mean age 45 years) of the CARDIA study at its year 20 follow-up examination: 2.6% in black men, 1.9% in black women, 1.2% in white men, and 0.1% in white women.[1]
- The prevalence of PR interval prolongation was observed to be 2.1% in Finnish middle-aged people, but the authors noted that the PR interval normalized in follow-up in 30% of these people.[2]
- Mobitz II second-degree AV block is rare in healthy individuals (≈0.003%), whereas Mobitz I (Wenckebach) is observed in 1% to 2% of healthy young people, especially during sleep.[1]
- The prevalence of third-degree AV block in the general adult population is ≈0.02% to 0.04%.[3,4]
- Third-degree AV block is very rare in apparently healthy individuals. Johnson et al[5] found only 1 case among >67 000 symptom-free individuals; Rose et al,[6] in their study of >18 000 civil servants, did not find any cases. On the other hand, among 293 124 patients with DM and 552 624 with hypertension enrolled with Veterans Health Administration hospitals, third-degree AV block was present in 1.1% and 0.6% of those patients, respectively.[7]
- Congenital complete AV block is estimated to occur in 1 of 15 000 to 20 000 live births,[8] An English register study estimated the incidence of infant complete AV block as 2.1

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Abbreviations Used in Chapter 16

ACCORD	Action to Control Cardiovascular Risk in Diabetes
AF	atrial fibrillation
AMI	acute myocardial infarction
ARIC	Atherosclerosis Risk in Communities study
ASSERT	Asymptomatic Atrial Fibrillation and Stroke Evaluation in Pacemaker Patients and the Atrial Fibrillation Reduction Atrial Pacing Trial
AV	atrioventricular
BMI	body mass index
BNP	B-type natriuretic peptide
BP	blood pressure
CABG	coronary artery bypass graft
CAD	coronary artery disease
CARDIA	Coronary Artery Risk Development in Young Adults
CHA_2DS_2-VASc	Clinical prediction rule for estimating the risk of stroke based on congestive heart failure, hypertension, diabetes mellitus, and sex (1 point each); age ≥75 y and stroke/transient ischemic attack/thromboembolism (2 points each); plus history of vascular disease, age 65 to 74 y, and (female) sex category
$CHADS_2$	Clinical prediction rule for estimating the risk of stroke based on congestive heart failure, hypertension, age ≥75 y, diabetes mellitus (1 point each), and prior stroke/transient ischemic attack/thromboembolism (2 points)
CHD	coronary heart disease
CHS	Cardiovascular Health Study
CI	confidence interval
CKD	chronic kidney disease
CVD	cardiovascular disease
DALY	disability-adjusted life-year
DM	diabetes mellitus
ECG	electrocardiogram
ED	emergency department
EF	ejection fraction
EMPHASIS-HF	Eplerenone in Mild Patients Hospitalization and Survival Study in Heart Failure
ESRD	end-stage renal disease
FHS	Framingham Heart Study
GBD	Global Burden of Diseases, Injuries, and Risk Factors Study
HD	heart disease
HF	heart failure
HR	hazard ratio
ICD-10	*International Classification of Diseases, 10th Revision*
ICD-9	*International Classification of Diseases, 9th Revision*
LV	left ventricular
MESA	Multi-Ethnic Study of Atherosclerosis
MI	myocardial infarction
NCHS	National Center for Health Statistics
NHDS	National Hospital Discharge Survey
NHLBI	National Heart, Lung, and Blood Institute
OHCA	out-of-hospital cardiac arrest
OR	odds ratio
ORBIT-AF	Outcomes Registry for Better Informed Treatment of Atrial Fibrillation
PAR	population attributable risk
PVT	polymorphic ventricular tachycardia
REGARDS	Reasons for Geographic and Racial Differences in Stroke
RR	relative risk
SBP	systolic blood pressure
SVT	supraventricular tachycardia
TdP	torsade de pointes
UI	uncertainty interval
VF	ventricular fibrillation
USD	US dollars
VT	ventricular tachycardia

per 100 000 live births.[9] Congenital complete heart block may be attributable to transplacental transfer of maternal anti-SSA/Ro-SSB/La antibodies.[8]

Risk Factors

- In healthy individuals without CVD or its risk factors from MESA, PR interval was longer with advancing age, in men compared with women, and in blacks compared with whites.[10]
- Although first-degree AV block and Mobitz type I second-degree AV block can occur in apparently healthy individuals, presence of Mobitz II second-degree or third-degree AV block usually indicates underlying HD, including CHD and HF.[1]
- Reversible causes of AV block include electrolyte abnormalities, drug-induced AV block, perioperative AV block attributable to hypothermia, or inflammation near the AV conduction system after surgery in this region. Some conditions may warrant pacemaker implantation because of the possibility of disease progression even if the AV block reverses transiently (eg, sarcoidosis, amyloidosis, and neuromuscular diseases).[11]
- Long sinus pauses and AV block can occur during sleep apnea. In the absence of symptoms, these abnormalities are reversible and do not require pacing.[12]

Prevention

- Detection and correction of reversible causes of acquired AV block could be of potential importance in preventing symptomatic bradycardia and other complications of AV block.[11]
- In utero detection of congenital AV block is possible by echocardiography.[13]

Aftermath

- In the FHS, PR interval prolongation (>200 ms) was associated with an increased risk of AF (HR, 2.06; 95% CI, 1.36–3.12),[14,15] pacemaker implantation (HR, 2.89; 95% CI, 1.83–4.57),[15] and all-cause mortality (HR, 1.44; 95% CI, 1.09–1.91).[15] Compared with individuals with a PR ≤200 ms, individuals with a PR interval >200 ms had an absolute increased risk per year of 1.04% for AF, 0.55% for pacemaker implantation, and 2.05% for death.
- Patients with abnormalities of AV conduction may be asymptomatic or may experience serious symptoms related to bradycardia, ventricular arrhythmias, or both.
- Decisions about the need for a pacemaker are influenced by the presence or absence of symptoms directly attributable to bradycardia. Permanent pacing improves survival in patients with third-degree AV block, especially if syncope has occurred.[11] Nevertheless, the overall prognosis depends to a large extent on the underlying HD.
- Although there is little evidence to suggest that pacemakers improve survival in patients with isolated first-degree AV block,[16] it is now recognized that marked first-degree AV block (PR >300 ms) can lead to symptoms even in the absence of higher degrees of AV block.[17]

Prognosis

- Investigators at Northwestern University compared older adult (age >60 years) outpatients with (n=470) and without (n=2090) asymptomatic bradycardia. Over a mean follow-up of 7.2 years, patients with asymptomatic bradycardia had a higher adjusted incidence of pacemaker insertion (HR, 2.14; 95% CI, 1.30–3.51; *P*=0.003), which appeared after a lag time of 4 years. However, the absolute rate of pacemaker implantation was low (<1% per year), and asymptomatic bradycardia was not associated with a higher risk of death.[18]

Sinus Node Dysfunction

Prevalence and Incidence

- The prevalence of sinus node dysfunction has been estimated to be between 403 and 666 per million, with an incidence rate of 63 per million per year requiring pacemaker therapy.[19]
- Sinus node dysfunction occurs in 1 of every 600 cardiac patients >65 years of age and accounts for ≈50% of implantations of pacemakers in the United States.[20,21]
- Sinus node dysfunction is commonly present with other causes of bradyarrhythmias (carotid sinus hypersensitivity in 33% of patients and advanced AV conduction abnormalities in 17%).[22,23]
- The incidence rate of sick sinus syndrome was 0.8 per 1000 person-years of follow-up in 2 biracial US cohorts, ARIC and CHS.[24] The incidence increased with advancing age (HR, 1.73; 95% CI, 1.47–2.05 per 5-year increment), and blacks were at 41% lower risk of sick sinus syndrome than their white counterparts (HR, 0.59; 95% CI, 0.37–0.98). Investigators projected that in the United States, the number of new cases of sick sinus syndrome per year would rise from 78 000 in 2012 to 172 000 in 2060.

Risk Factors

- The causes of sinus node dysfunction can be classified as intrinsic (secondary to pathological conditions involving the sinus node) or extrinsic (caused by depression of sinus node function by external factors such as drugs or autonomic influences).[25]
- Sinus node dysfunction may occur at any age but is primarily a disease of the elderly, with the average being ≈68 years of age.[20]
- Idiopathic degenerative disease is probably the most common cause of sinus node dysfunction.[26]
- Collected data from 28 different studies on atrial pacing for sinus node dysfunction showed a median annual incidence of complete AV block of 0.6% (range, 0%–4.5%) with a total prevalence of 2.1% (range, 0%–11.9%). This suggests that the degenerative process also affects the specialized conduction system, although the rate of progression is slow and does not dominate the clinical course of disease.[27]
- Ischemic HD can be responsible for one third of cases of sinus node dysfunction. Transient sinus node dysfunction can complicate MI; it is common during inferior MI and is caused by autonomic influences. Cardiomyopathy, long-standing hypertension, infiltrative disorders (eg, amyloidosis and sarcoidosis), collagen vascular disease, and surgical trauma can also result in sinus node dysfunction.[28,29]

- In the CHS and ARIC studies, factors associated with incident sick sinus syndrome included higher mean BMI, height, N-terminal pro-BNP, cystatin C, QRS interval, and lower heart rate, as well as prevalence of hypertension and right bundle branch.[24]

Aftermath

(See Chart 16-2.)

- The course of sinus node dysfunction is typically progressive, with 57% of patients experiencing symptoms over a 4-year period if untreated and a 23% prevalence of syncope over the same time frame.[30]
- Approximately 50% of patients with sinus node dysfunction develop tachy-brady syndrome over a lifetime; such patients have a higher risk of stroke and death. The survival of patients with sinus node dysfunction appears to depend primarily on the severity of underlying cardiac disease and is not significantly changed by pacemaker therapy.[31–33]
- In a retrospective study,[34] patients with sinus node dysfunction who had pacemaker therapy were followed up for 12 years; at 8 years, mortality among those with ventricular pacing was 59% compared with 29% among those with atrial pacing. This discrepancy may be attributed to selection bias. For instance, the physiological or anatomic disorder (eg, fibrosis of conductive tissue) that led to the requirement for the particular pacemaker may have influenced prognosis, rather than the type of pacemaker used.
- In a multicenter study from the Netherlands of individuals with bradycardia treated with pacemaker implantation, the actuarial 1-, 3-, 5-, and 7-year survival rates were 93%, 81%, 69%, and 61%, respectively. Individuals without CVD at baseline had similar survival rates as age- and sex-matched control subjects.[35]
- The incidence of sudden death is extremely low, and sinus node dysfunction does not appear to affect survival whether untreated or treated with pacemaker therapy.[11]
- SVT including AF occurs in 47% to 53% of patients with sinus node dysfunction.[33,36]
- On the basis of records from the NHDS, age-adjusted pacemaker implantation rates increased progressively from 370 per million in 1990 to 612 per million in 2002. This escalating implantation rate is attributable to increasing implantation for isolated sinus node dysfunction; implantation for sinus node dysfunction increased by 102%, whereas implantation for all other indications did not increase.[37]
- In patients paced for sick sinus syndrome, the CHA_2DS_2-VASc score is associated with an increased risk of stroke and death, even in individuals without AF at baseline.[38]

SVT (Excluding AF and Atrial Flutter)

ICD-9 427.0; ICD-10 I47.1.

Mortality—138. Any-mention mortality—1293. Hospital discharges—23 000.

Prevalence and Incidence

(See Chart 16-3.)

- Data from the Marshfield Epidemiologic Study Area in Wisconsin suggested the incidence of documented paroxysmal SVT is 35 per 100 000 person-years. The mean age at SVT onset was 57 years, and both female sex and age >65 years were significant risk factors.[39]
- A review of ED visits from 1993 to 2003 revealed that 550 000 visits were for SVT (0.05% of all visits; 95% CI, 0.04%–0.06%), or ≈50 000 visits per year. Of these patients, 24% (95% CI, 15%–34%) were admitted to the hospital, and 44% (95% CI, 32%–56%) were discharged without specific follow-up.[40]
- The prevalence of SVT that is clinically undetected is likely much greater than the estimates from ED visits and electrophysiology procedures would suggest. For example, among a random sample of 604 participants in Finland, 7 (1.2%) fulfilled the diagnostic criteria for inappropriate sinus tachycardia.[41]
- Of 1383 participants in the Baltimore Longitudinal Study of Aging undergoing maximal exercise testing, 6% exhibited SVT during the test; increasing age was a significant risk factor. Only 16% exhibited >10 beats of SVT, only 4% were symptomatic, and the SVT participants were more likely to develop spontaneous SVT or AF.[42]
- From the surface ECG, the prevalence of atrial tachycardia is estimated to be 0.34% in asymptomatic patients and 0.46% in symptomatic patients.[43]

Aftermath

- Rare cases of incessant SVT can lead to a tachycardia-induced cardiomyopathy,[44] and rare cases of sudden death attributed to SVT as a trigger have been described.[45]
- A California administrative database study suggested that after the exclusion of people with diagnosed AF, SVT was associated with an adjusted doubling of the risk of stroke in follow-up (HR, 2.10; 95% CI, 1.69–2.62). The absolute stroke rate was low, however. The cumulative stroke rate was 0.94% (95% CI, 0.76%–1.16%) in patients with SVT versus 0.21% (95% CI, 0.21%–0.22%; $P<0.001$, log-rank test) in those without SVT.[46]

Specific Types

- Among those presenting for invasive electrophysiological study and ablation, AV nodal reentrant tachycardia (a circuit that requires 2 AV nodal pathways) is the most common mechanism of SVT[47,48] and usually represents the majority of cases (56% of 1 series of 1754 cases from Loyola University Medical Center).[48]
- AV reentrant tachycardia (an arrhythmia that requires the presence of an extranodal connection between the atria and ventricles or specialized conduction tissue) is the second most common[49,50] type of SVT (27% in the Loyola series),[48] and atrial tachycardia is the third most common (17% in the Loyola series).[48]
- In the pediatric population, AV reentrant tachycardia is the most common SVT mechanism, followed by AV nodal reentrant tachycardia and then atrial tachycardia.[51]
- AV reentrant tachycardia prevalence decreases with age, whereas AV nodal reentrant tachycardia and atrial tachycardia prevalences increase with advancing age.[48]
- The majority of AV reentrant tachycardia patients in the Loyola series were men (55%), whereas the majority of patients with AV nodal reentrant tachycardia (70%) or atrial tachycardia (62%) were women.[48]

- Multifocal atrial tachycardia is an arrhythmia that is commonly confused with AF and is characterized by 3 distinct P-wave morphologies, irregular R-R intervals, and a rate >100 beats per minute. It is uncommon in both children[49] and adults,[50] with a prevalence in hospitalized adults estimated at 0.05% to 0.32%.[52,53] The average age in adults is 70 to 72 years. Adults with multifocal atrial tachycardia have a mortality rate that is high, with estimates around 45%, but this is generally ascribed to the underlying condition(s).[50,54]

Wolff-Parkinson-White Syndrome

- Wolff-Parkinson-White syndrome, a diagnosis reserved for those with both ventricular preexcitation (evidence of an anterograde conducting AV accessory pathway on a 12-lead ECG) and tachyarrhythmias,[55] deserves special attention because of the associated risk of sudden death. Sudden death is generally attributed to rapid heart rates in AF conducting down an accessory pathway and leading to VF.[56,57] Of note, AF is common in Wolff-Parkinson-White patients, and surgical or catheter ablation of the accessory pathway often results in elimination of the AF.[58]
- Ventricular preexcitation with or without tachyarrhythmia was observed in 0.11% of 47 358 ECGs in adults participating in 4 large Belgian epidemiological studies[52] and in 0.17% of 32 837 Japanese high school students in ECGs obtained by law before the students entered school.[53]
- Asymptomatic adults with ventricular preexcitation appear to be at no increased risk of sudden death compared with the general population,[56,57,59,60] although certain characteristics found during invasive electrophysiological study (including inducibility of AV reentrant tachycardia or AF, accessory pathway refractory period, and the shortest R-R interval during AF) can help risk stratify these patients.[57,61]
- In a single-center prospective registry study of 2169 patients who agreed to undergo an electrophysiology study for Wolff-Parkinson-White syndrome from 2005 to 2010, 1168 (206 asymptomatic) underwent radiofrequency ablation, none of whom had malignant arrhythmias or VF in up to 8 years of follow-up. Of those who did not receive radiofrequency ablation (n=1001; 550 asymptomatic) in follow-up, 1.5% had VF, most of whom (13 of 15) were children. The authors noted that poor prognosis was related to accessory pathway electrophysiological properties rather than patient symptoms.[62]
- In a meta-analysis of 20 studies involving 1869 asymptomatic patients with a Wolff-Parkinson-White ECG pattern followed up for a total of 11 722 person-years, the risk of sudden death in a random effects model that was used because of heterogeneity across studies was estimated to be 1.25 (95% CI, 0.57–2.19) per 1000 person-years. Risk factors for sudden death included male sex, inclusion in a study of children (<18 years of age), and inclusion in an Italian study.[63]
- Although some studies in asymptomatic children with ventricular preexcitation suggest a benign prognosis,[59,64] others suggest that electrophysiological testing can identify a group of asymptomatic children with a risk of sudden death or VF as high as 11% over 19 months of follow-up.[65] In a pediatric hospital retrospective review of 444 children with Wolff-Parkinson-White syndrome, 64% were symptomatic at presentation, and 20% had onset of symptoms in follow-up. The incidence of sudden death was 1.1 per 1000 person years in patients without structural HD.[66]

Subclinical Atrial Tachyarrhythmias, Unrecognized AF, Screening for AF

Device-Detected AF

- Pacemakers and defibrillators have increased clinician awareness of the frequency of subclinical AF and atrial high-rate episodes in individuals without a documented history of AF. Several studies have suggested that device-detected high-rate atrial tachyarrhythmias are surprisingly frequent and are associated with an increased risk of AF,[61] thromboembolism,[61,67] and total mortality.[61]
- Investigators in the ASSERT study prospectively enrolled 2580 patients with a recent pacemaker or defibrillator implantation who were ≥65 years of age, had a history of hypertension, and had no history of AF. They classified individuals by presence versus absence of subclinical atrial tachyarrhythmias (defined as atrial rate >190 beats per minute for >6 minutes in the first 3 months) and conducted follow-up for 2.5 years.[68] Subclinical atrial tachyarrhythmias in the first 3 months occurred in 10.1% of the patients and were associated with the following:
  - —An almost 6-fold higher risk of clinical AF (HR, 5.56; 95% CI, 3.78–8.17; $P<0.001$)
  - —A more than doubling in the adjusted risk of the primary end point, ischemic stroke or systemic embolism (HR, 2.50; 95% CI, 1.28–4.89; $P<0.008$)
  - —An annual ischemic stroke or systemic embolism rate of 1.69% (versus 0.69% in those without)
  - —A 13% PAR for ischemic stroke or systemic embolism
- Over the subsequent 2.5 years of follow-up, an additional 34.7% of the patients had subclinical atrial tachyarrhythmias, which were 8-fold more frequent than clinical AF episodes.[68]
- A pooled analysis of 5 prospective studies in patients without permanent AF revealed that over 2 years of follow-up, cardiac implanted electronic devices detected ≥5 minutes of AF in 43% of the patients (total n=10 016). Adjustment for $CHADS_2$ score and anticoagulation revealed that AF burden was associated with an increased risk of stroke.[69]

Community Screening

- In a community-based study in Sweden, all inhabitants aged 75 to 76 years were invited to a stepwise screening program for AF. Of 848 participants, 10 had clinically unrecognized AF diagnosed on a 12-lead ECG. Of 403 individuals with ≥2 stroke risk factors who completed a 2-week, once-a-day handheld ECG event recorder, an additional 30 were diagnosed with paroxysmal AF. The study suggests that the burden of unrecognized AF in the community is higher than appreciated.[70]
- There have been 2 recent systematic reviews regarding the effectiveness of screening to detect unknown AF.

—Lowres et al[71] identified 30 separate studies that included outpatient clinics or community screening. In individuals without a prior diagnosis of AF, they observed that 1.0% (95% CI, 0.89%–1.04%) of those screened had AF (14 studies, n=67 772), whereas among those individuals ≥65 years of age, 1.4% (95% CI, 1.2%–1.6%; 8 studies, n=18 189) had AF.

—Another systematic review by Moran et al[72] observed that in individuals >65 years of age, systematic screening (OR, 1.57; 95% CI, 1.08–2.26) and opportunistic screening (OR, 1.58; 95% CI, 1.10–2.29) were associated with enhanced detection of AF. The number needed to screen by either method was ≈170 individuals.

- There has been increasing interest in the use of smart phone technology to aid in community screening.[73,74]

AF and Atrial Flutter

ICD-9 427.3; ICD-10 I48.

Prevalence

(See Chart 16-4.)

- Estimates of the prevalence of AF in the United States ranged from ≈2.7 million to 6.1 million in 2010,[75,76] and AF prevalence is estimated to rise to 12.1 million in 2030.[77]
- In the European Union, the prevalence of AF in adults >55 years of age was estimated to be 8.8 million (95% CI, 6.5–12.3 million) in 2010 and was projected to rise to 17.9 million in 2060 (95% CI, 13.6–23.7 million).[78]
- Data from a California health plan suggest that compared with whites, blacks (OR, 0.49; 95% CI, 0.47–0.52), Asians (OR, 0.68; 95% CI, 0.64–0.72), and Hispanics (OR, 0.58; 95% CI, 0.55–0.61) have significantly lower adjusted prevalences of AF.[79]
- Data from the NHDS/NCHS (1996–2001) on cases that included AF as a primary discharge diagnosis found the following:

  —Approximately 44.8% of patients were men.

  —The mean age for men was 66.8 years versus 74.6 years for women.

  —The racial breakdown for admissions was 71.2% white, 5.6% black, and 2.0% other races (20.8% were not specified).

  —Black patients were much younger than patients of other races.

- Among Medicare patients aged ≥65 years, diagnosed from 1993 to 2007, the prevalence of AF increased ≈5% per year, from ≈41.1 per 1000 beneficiaries to 85.5 per 1000 beneficiaries.[80]

Incidence

(See Table 16-1 and Chart 16-5.)

- Data from the NHDS/NCHS (1996–2001) on cases that included AF as a primary discharge diagnosis found the following:

  —The incidence in men ranged from 20.6 per 100 000 people per year for patients between 15 and 44 years of age to 1077.4 per 100 000 people per year for patients ≥85 years of age.

  —In women, the incidence ranged from 6.6 per 100 000 people per year for patients between 15 and 44 years of age to 1203.7 per 100 000 people per year for those ≥85 years of age.

- Data from California administrative databases were analyzed regarding racial variation in incidence of AF. After adjustment for AF risk factors, compared with their white counterparts, lower incidence rates were found in blacks (HR, 0.84; 95% CI, 0.82–0.85; $P<0.001$), Hispanics (HR, 0.78; 95% CI, 0.77–0.79; $P<0.001$), and Asians (HR, 0.78; 95% CI, 0.77–0.79; $P<0.001$).[81]
- In a Medicare sample, the incidence of AF was ≈28 per 1000 person-years and did not change substantively between 1993 and 2007. Of individuals with incident AF in 2007, ≈55% were women, 91% were white, 84% had hypertension, 36% had HF, and 30% had cerebrovascular disease.[80]
- Using data from a health insurance claims database covering 5% of the United States, the incidence of AF was estimated at 1.6 million cases in 2010 and was projected to increase to 2.6 million cases in 2030.[77]

Mortality

- In 2013, AF was mentioned on 131 914 US death certificates and was the underlying cause in 20 738 of those deaths (NCHS, NHLBI).[82]
- In adjusted analyses from the FHS, AF was associated with an increased risk of death in both men (OR, 1.5; 95% CI, 1.2–1.8) and women (OR, 1.9; 95% CI, 1.5–2.2).[83] Furthermore, there was an interaction with sex, such that AF appeared to diminish the survival advantage typically observed in women.
- In Medicare beneficiaries ≥65 years of age with new-onset AF, mortality decreased modestly but significantly between 1993 and 2007. In 2007, the age- and sex-adjusted mortality at 30 days was 11%, and at 1 year, it was 25%.[80]
- A study of >4600 patients diagnosed with first AF showed that risk of death within the first 4 months after the AF diagnosis was high. The most common causes of CVD death were CAD, HF, and ischemic stroke, which accounted for 22%, 14%, and 10%, respectively, of the early deaths (within the first 4 months) and 15%, 16%, and 7%, respectively, of the late deaths.[84]
- Although stroke is the most feared complication of AF, a recent clinical trial reported that stroke accounted for only ≈7.0% of deaths in AF, with sudden cardiac death (22.25%), progressive HF (15.1%), and noncardiovascular death (35.8%) accounting for the majority of deaths.[85]
- AF is also associated with increased mortality in individuals with other cardiovascular conditions and procedures, including HF,[86,87] HF with preserved EF[88,89] and reduced EF[88] (with a meta-analysis suggesting a worse prognosis in preserved versus reduced EF[88]), MI,[90,91] CABG[92–95] (both short-term and long-term[95]), and stroke.[96] In noncardiovascular conditions, AF also is associated with an increased risk of death, including in DM,[97] ESRD,[98] sepsis,[99,100] and noncardiac surgery.[101]

Lifetime Risk and Cumulative Risk

(See Chart 16-6.)

- Participants of largely European ancestry in the NHLBI-sponsored FHS were followed up from 1968 to 1999. At 40 years of age, remaining lifetime risks for AF were 26.0% for men and 23.0% for women. At 80 years of age, lifetime risks for AF were 22.7% for men and 21.6% for women. In further analysis, counting only those who had development of AF without prior or concurrent HF or MI, lifetime risk for AF was ≈16%.[102] Estimates of lifetime risks of AF were similar in the Rotterdam Study.[103]
- Investigators from the NHLBI-sponsored ARIC study observed that the cumulative risk of AF was 21% in white men, 17% in white women, and 11% in African Americans of both sexes by 80 years of age.[104]

Risk Factors

- Standard risk factors
  - —ARIC,[91] the FHS,[13,105,106] and the Women's Health Study[107] have developed risk prediction models to predict new-onset AF. Predictors of increased risk of new-onset AF include advancing age, European ancestry, body size (greater height and BMI), electrocardiography features (LV hypertrophy, left atrial enlargement), DM, BP (SBP and hypertension treatment), and presence of CVD (CHD, HF, valvular HD).
  - —More recently, the ARIC, CHS, and FHS investigators developed and validated a risk prediction model.[93]
  - —Other consistently reported risk factors for AF include clinical and subclinical hyperthyroidism,[108,109] CKD,[110] and moderate[111] or heavy alcohol consumption.[112]
- Family history
  - —Although unusual, early-onset familial lone AF has long been recognized as a risk factor.[113,114]
  - —In the past decade, the heritability of AF in the community has been appreciated. In studies from the FHS
    - Adjusted for coexistent risk factors, having at least 1 parent with AF was associated with a 1.85-fold increased risk of AF in the adult offspring (multivariable-adjusted 95% CI, 1.12–3.06; *P*=0.02).[115]
    - A history of a first-degree relative with AF also was associated with an increased risk of AF (HR, 1.40; 95% CI, 1.13–1.74).[92] The risk was greater if the first-degree relative's age of onset was ≤65 years (HR, 2.01; 95% CI, 1.49–2.71) and with each additional affected first-degree relative (HR, 1.24; 95% CI, 1.05–1.46).[116]
  - —Similar findings were reported from Sweden.[117]
- Genetics
  - —Mutations in genes coding channels (sodium and potassium), gap junction proteins, and signaling have been described, often in lone AF or familial AF series, but they are responsible for few cases of AF in the community.[118]
  - —Meta-analyses of genome-wide association studies have revealed single-nucleotide polymorphisms on chromosomes 4q25 (upstream of *PITX2*),[119–121] 16q22 (*ZFHX3*),[120,122] and 1q21 (*KCNN3*),[121] as well as 6 other novel susceptibility loci (near *PRRX1*, *CAV1*, *C9orf3*, *SYNPO2L*, *SYNE2*, and *HCN4*)[123] are associated with AF in individuals of European and Japanese ancestry.[124] Although an area of intensive inquiry, the causative single-nucleotide polymorphisms and the functional basis of the associations have not been revealed.
  - —Some studies suggest that genetic markers of AF may improve risk prediction for AF over models that include clinical factors.[107]

Awareness

- In a US national biracial study of individuals with AF, compared with whites, blacks had approximately one third the likelihood (OR, 0.32; 95% CI, 0.20–0.52) of being aware that they had AF.[125]

Prevention

(See Chart 16-7.)

- Data from the ARIC study indicated that having at least 1 elevated risk factor explained 50% and having at least 1 borderline risk factor explained 6.5% of incident AF cases. The estimated overall incidence rate per 1000 person-years at a mean age of 54.2 years was 2.19 for those with optimal risk, 3.68 for those with borderline risk, and 6.59 for those with elevated risk factors.[126]
- Hypertension accounted for ≈14%[127] to 22%[126] of AF cases.
- Observational data from the CHS suggested that moderate-intensity exercise (such as regular walking) was associated with a lower risk of AF (HR, 0.72).[128] However, data from many studies suggested that vigorous-intensity exercise 5 to 7 days a week was associated with a slightly increased risk of AF (HR, 1.20; *P*=0.04).[129]
- Meta-analyses have suggested that renin-angiotensin system blockers may be useful in primary and secondary (recurrences) prevention of AF in trials of hypertension, after MI, in HF, and after cardioversion.[96,130] However, the studies were primarily secondary or post hoc analyses, and the results were fairly heterogeneous. Recently, in an analysis of the EMPHASIS-HF trial, in one of many secondary outcomes, eplerenone was nominally observed to reduce the incidence of new-onset AF.[131]
- Intensive glycemic control was not found to prevent incident AF in the ACCORD study.[97]
- Although heterogeneous in their findings, modest-sized short-term studies suggested that the use of statins might prevent AF; however, larger longer-term studies do not provide support for the concept that statins are effective in AF prevention.[132]
- Treatment of obstructive sleep apnea has been noted to decrease risk of recurrent AF, after cardioversion[133] and ablation,[134] but its role in primary prevention is unproven.
- In a national outpatient registry of AF patients (ORBIT-AF), 93.5% had indications for guideline-based primary or secondary prevention in addition to oral anticoagulants; however, only 46.6% received all guideline-indicated therapies, consistent with an underutilization of evidenced-based preventive therapies for comorbid conditions in individuals with AF.[134] Predictors of not receiving all guideline-indicated therapies included frailty, comorbid illness, geographic region,

and antiarrhythmic drug therapy. Factors most strongly associated with the 17.1% warfarin discontinuation rate in the first year prescribed included hospitalization because of bleeding (OR, 10.9; 95% CI, 7.9–15.0), prior catheter ablation (OR, 1.8; 95% CI, 1.4–2.4), noncardiovascular/nonbleeding hospitalization (OR, 1.8; 95% CI, 1.4–2.2), cardiovascular hospitalization (OR, 1.6; 95% CI, 1.3–2.0), and permanent AF (OR, 0.25; 95% CI, 0.17–0.36).[134a]

- In individuals with AF, there are increasing data supporting the importance of risk factor modification for secondary prevention of AF recurrence and improved symptoms. Randomized trials of overweight or obese patients referred for management of symptomatic paroxysmal or persistent AF to an Adelaide, Australia, arrhythmia clinic demonstrated that weight loss was associated with a dose-dependent greater likelihood of being arrhythmia free[135] and reporting a lower symptom burden.[135,136] Similarly, in individuals referred for catheter ablation, those who agreed to aggressive risk factor modification had lower symptom burden in follow-up.[137]

Aftermath

(See Chart 16-8.)

- Thromboembolism excluding stroke
  - —In a Danish population-based registry of individuals 50 to 89 years of age discharged from the hospital, individuals with new-onset AF had an elevated risk of thromboembolic events to the aorta, renal mesenteric, pelvic, and peripheral arteries. The event rate was 2 to 10 per 1000 person-years. Compared with referents in the Danish population, the RR of diagnosed extracranial embolism was 4.0 (95% CI, 3.5–4.6) in men and 5.7 (95% CI, 5.1–6.3) in women.[138]
- Stroke
  - —Stroke rates per 1000 patient-years declined in AF patients taking anticoagulants, from 46.7 in 1992 to 19.5 in 2002, for ischemic stroke but remained fairly steady for hemorrhagic stroke (1.6–2.9).[139]
  - —Before the widespread use of anticoagulants, after accounting for standard stroke risk factors, AF was associated with a 4- to 5-fold increased risk of ischemic stroke.[140] Although the RR of stroke associated with AF did not vary (≈3- to 5-fold increased risk) substantively with advancing age, the proportion of strokes attributable to AF increased significantly. In the FHS, AF accounted for ≈1.5% of strokes in individuals 50 to 59 years of age and ≈23.5% in those 80 to 89 years of age.[140]
  - —Paroxysmal, persistent, and permanent AF all appeared to increase the risk of ischemic stroke to a similar degree.[130]
  - —AF was also an independent risk factor for ischemic stroke severity, recurrence, and mortality.[96] In one study, individuals who had AF and were not treated with anticoagulants had a 2.1-fold increase in risk for recurrent stroke and a 2.4-fold increase in risk for recurrent severe stroke.[141]
  - —Studies have demonstrated an underutilization of warfarin therapy. In a recent meta-analysis, men and individuals with prior stroke were more likely to receive warfarin, whereas factors associated with lower use included alcohol and drug abuse, noncompliance, warfarin contraindications, dementia, falls, both gastrointestinal and intracranial hemorrhage, renal impairment, and advancing age.[142] The underutilization of anticoagulation in AF has been demonstrated to be a global problem.[143]
- Cognition
  - —Individuals with AF have an adjusted 2-fold increased risk of dementia.[144]
  - —A meta-analysis of 21 studies indicated that AF was associated with an increased risk of cognitive impairment in patients after stroke (RR, 2.70; 95% CI, 1.82–4.00) and in patients without a history of stroke (RR 1.37; 95% CI, 1.08–1.73). The risk of dementia was similarly increased (RR 1.38; 95% CI, 1.22–1.56]).[145]
  - —In individuals with AF in Olmsted County, MN, the cumulative rate of dementia at 1 and 5 years was 2.7% and 10.5%, respectively.[131]
- Physical disability and subjective health
  - —AF has been associated with physical disability and poor subjective health.[146,147] A recent systematic review suggested that among individuals with AF, moderate-intensity activity improved exercise capacity and quality of life.[129]
- HF
  - —AF and HF share many antecedent risk factors, and ≈40% of individuals with either AF or HF will develop the other condition.[86]
  - —In the community, estimates of the incidence of HF in individuals with AF ranged from 3.3[86] to 4.4[148] per 100 person-years of follow-up.
  - —Among older adults with AF in Medicare, the 5-year event rate was high, with rates of death and HF exceeding those for stroke. Higher event rates after new-onset AF were associated with older age and higher mean $CHADS_2$ score.[149]
- MI
  - —In the REGARDS study, in models that adjusted for standard risk factors, AF was associated with a 70% increased risk of incident MI (HR, 1.96; 95% CI, 1.52–2.52); the risk was higher in women and blacks. In individuals with AF, the age-adjusted incidence rate per 1000 person-years was 12.0 (95% CI, 9.6–14.9) in those with AF compared with 6.0 (95% CI, 5.6–6.6) in those without AF.[150]
- CKD
  - —In a Japanese community-based study, individuals with AF had approximately a doubling in increased risk of developing kidney dysfunction or proteinuria, even in individuals without baseline DM or hypertension. Per 1000 person-years of follow-up, the incidence of kidney dysfunction was 6.8 in individuals without and 18.2 in individuals with AF at baseline.[151]
  - —In a Kaiser Permanente Study of individuals with CKD, new-onset AF was associated with an adjusted 1.67-fold

increased risk of developing ESRD compared with those without AF (74 versus 64 per 1000 person-years of follow-up).[152]

- Sudden cardiac death and VF
  - —In a study that examined data from 2 population-based studies, AF was associated with a doubling in the risk of sudden cardiac death after accounting for baseline and time-varying confounders. In ARIC, the unadjusted incidence rate was 1.30 (95% CI, 1.14–1.47) in those without AF and 2.89 (95% CI, 2.00–4.05) in those with AF; corresponding rates in CHS were 3.82 (95% CI, 3.35–4.35) and 12.00 (95% CI, 9.45–15.25), respectively. The multivariable-adjusted HR associated with AF for sudden death was 2.47 (95% CI, 1.95–3.13).[153]
  - —An increased risk of VF was observed in a community-based case-control study from the Netherlands. Individuals with ECG-documented VF during OHCA were matched with non-VF community control subjects. The prevalence of AF in the 1397 VF cases was 15.4% versus 2.6% in the community control subjects. Individuals with AF had an overall adjusted 3-fold increased risk of VF (adjusted OR, 3.1; 95% CI, 2.1–4.5). The association was similar across age and sex categories and was observed in analyses of individuals without comorbidities, without AMI, and not using antiarrhythmic or QT-prolonging drugs.[154]

Hospitalization

- Data from the NHDS/NCHS 2010 on cases that included AF as a primary discharge diagnosis found the following[155]:
  - —Hospital discharges—479 000.
  - —Approximately 50.8% of patients were males.
  - —The mean age for males was 65.5 years versus 74.1 years for females.
  - —The rate of AF hospitalization in males ranged from 32.6 per 100 000 people per year for patients between 15 and 44 years of age to 1275.8 per 100 000 people per year for patients ≥85 years of age.
  - —The rate of AF hospitalization in females ranged from 5.4 per 100 000 people per year for patients between 15 and 44 years of age to 1323.4 per 100 000 people per year for those ≥85 years of age.
- From 1996 to 2001, hospitalizations with AF as the first-listed diagnosis increased by 34%.[156]
- On the basis of Medicare and MarketScan databases, annually, individuals with AF (37.5%) are approximately twice as likely to be hospitalized as age- and sex-matched control subjects (17.5%).[157]

Cost

(See Chart 16-9.)

- Investigators examined Medicare and MarketScan databases (2004–2006) to estimate costs attributed to AF in 2008 US dollars[157]:
  - —Annual total direct costs for AF patients were ≈$20 670 versus ≈$11 965 in the control group, for an incremental per-patient cost of $8705.
  - —Extrapolating to the US population, it is estimated that the incremental cost of AF was ≈$26 billion, of which $6 billion was attributed to AF, $9.9 billion to other cardiovascular expenses, and $10.1 billion to noncardiovascular expenses.

Temporal Trends

- During 50 years of observation of the FHS (1958–1967 to 1998–2007) the age-adjusted prevalence and incidence of AF approximately quadrupled. However, when only AF that was ascertained on ECGs routinely collected in the FHS was considered, the prevalence but not the incidence increased, which suggests that part of the changing epidemiology was attributable to enhanced surveillance. Although the prevalence of most risk factors changed over time, the hazards associated with specific risk factors did not change. Hence, the PAR associated with BMI, hypertension treatment, and DM increased (consistent with increasing prevalence). Over time, the multivariable-adjusted hazards of stroke and mortality associated with AF declined by 74% and 25%, respectively.[158]
- In data from the ARIC study, the prevalence of AF in the setting of MI increased slightly, from 11% to 15% between 1987 and 2009. However, the increased risk of death (OR, 1.47; 95% CI, 1.07–2.01) in the year after MI accompanied by AF did not change over time.[159]

Global Burden of AF

(See Chart 16-10.)

- The vast majority of research on the epidemiology of AF has been conducted in Europe and North America. Investigators from the GBD project noted that the global prevalence, incidence, mortality, and DALYs associated with AF increased from 1990 to 2010.[160]
  - —The 2010 worldwide prevalence of AF was estimated at 33.5 million: 20.9 million men (95% UI, 19.5–22.2 million) and 12.6 million women (95% UI, 12.0–13.7). In 2010, the age-adjusted AF prevalence per 100 000 people was estimated to be 596.2 (95% UI, 558.4–636.7) in men and 373.1 (95% UI, 347.9–402.2) in women.
  - —The 2010 estimated annual AF incidence per 100 000 person-years was estimated to be 77.5 (95% UI, 65.2–95.4) in men and 59.5 (95% UI, 49.9–74.9) in women.
  - —Although AF accounted for <1% of global deaths, the age-adjusted mortality rate was 1.6 (95% UI, 1.0–2.4) in men and 1.7 (95% UI, 1.4–2.2) in women in 2010.
  - —The 2010 estimated DALYs per 100 000 population from AF were 64.5 (95% UI, 46.8–84.2) and 45.9 (95% UI, 35.7–58.5) in 2010; DALYs were higher in developed than in developing countries.

Tachycardia

ICD-9 427.0, 427.1, 427.2; ICD-10 I47.1, I47.2, I47.9.

Mortality—733. Any-mention mortality—6497. Hospital discharges—78 000.

Monomorphic VT

Prevalence and Incidence

- The true prevalence and incidence of monomorphic VT in the US general population are not known.

- Of 150 consecutive patients with wide-complex tachycardia subsequently studied by invasive electrophysiological study, 122 (81%) had VT; the remainder had SVT.[161]
- Of patients with ventricular arrhythmias presenting for invasive electrophysiological studies, 11% to 21% had no structural HD, and the majority of those with structural HD had CAD.[162,163]
- In 634 patients with implantable cardioverter-defibrillators who had structural HD (including both primary and secondary prevention patients) followed up for a mean 11±3 months, ≈80% of potentially clinically relevant ventricular tachyarrhythmias were attributable to VT amenable to antitachycardia pacing (which implies a stable circuit and therefore monomorphic VT).[164] Because therapy may have been delivered before spontaneous resolution occurred, the proportion of these VT episodes with definite clinical relevance is not known.
- Of those with VT in the absence of structural HD, right ventricular outflow tract VT is the most common form.[165]
- Among 2099 subjects (mean age, 52 years; 52.2% male) without known CVD, exercise-induced nonsustained VT occurred in nearly 4% and was not independently associated with total mortality.[166]

Aftermath

- Although the prognosis of those with VT or frequent premature ventricular contractions in the absence of structural HD is good,[162,165] a potentially reversible cardiomyopathy may develop in patients with very frequent premature ventricular contractions,[167,168] and some cases of sudden death attributable to short-coupled premature ventricular contractions have been described.[169,170]

Polymorphic VT

Prevalence and Incidence

- The true prevalence and incidence of PVT in the US general population are not known.
- During ambulatory cardiac monitoring, PVT prevalence ranged from 0.01% to 0.15%[171,172]; however, among patients who developed sudden cardiac death during ambulatory cardiac monitoring, PVT was detected in 30% to 43%.[172–174]
- In the setting of AMI, the prevalence of PVT ranged from 1.2% to 2%.[175,176]
- Out-of-hospital PVT is estimated to be present in ≈25% of all cardiac arrest cases involving VT.[177,178]
- A prevalence range of 15% to 19% was reported during electrophysiological study in patients resuscitated from cardiac arrest.[174,179,180]

Risk Factors

- PVT in the setting of a normal QT interval is most frequently seen in the context of acute ischemia or MI.[181,182]
- Less frequently, PVT with a normal QT interval can occur in patients without apparent structural HD. Catecholaminergic PVT, which is discussed under inherited arrhythmic syndromes, is one such disorder.
- A prolonged QT interval, whether acquired (drug induced) or congenital, is a common cause of PVT. Drug-induced prolongation of the QT interval that causes PVT is discussed under TdP, whereas congenital prolonged QT interval is discussed under inherited arrhythmic syndromes.

Aftermath

- The presentation of PVT can range from a brief, asymptomatic, self-terminating episode to recurrent syncope or sudden cardiac death.[183]
- The overall hospital discharge rate (survival) of PVT has been estimated to be ≈28%.[184]

Torsade de Pointes

Prevalence and Incidence

- The true incidence and prevalence of drug-induced TdP in the US general population are largely unknown.
- By extrapolating data from non-US registries,[185] it has been estimated that 12 000 cases of drug-induced TdP occur annually in the United States.[175]
- A prospective, active surveillance, Berlin-based registry of 51 hospitals observed that the annual incidence of symptomatic drug-induced QT prolongation in adults was 2.5 per million men and 4.0 per million women. The authors reported 42 potentially associated drugs, including metoclopramide, amiodarone, melperone, citalopram and levomethdaone. The mean age of patients with QT prolongation/TdP was 57±20 years, and the majority of the cases occurred in women (66%), out of the hospital (60%).[186]
- The prevalence of drug-induced prolongation of QT interval and TdP is 2 to 3 times higher in women than in men.[176]
- With the majority of QT-interval–prolonging drugs, drug-induced TdP may occur in 3% to 15% of patients.[174]
- Antiarrhythmic drugs with QT-interval–prolonging potential carry a 1% to 3% risk of TdP over 1 to 2 years of exposure.[187]

Risk Factors

- TdP is usually related to administration of QT-interval–prolonging drugs.[188] An up-to-date list of drugs with the potential to cause TdP is available at a Web site maintained by the University of Arizona Center for Education and Research on Therapeutics.[189]
- Specific risk factors for drug-induced TdP include prolonged QT interval, female sex, advanced age, bradycardia, hypokalemia, hypomagnesemia, LV systolic dysfunction, and conditions that lead to elevated plasma concentrations of causative drugs, such as kidney disease, liver disease, drug interactions, or some combination of these.[175,190,191]
- Predisposition was also noted in patients who had a history of ventricular arrhythmia and who experienced a recent symptomatic increase in the frequency and complexity of ectopy.[192]
- Drug-induced TdP rarely occurs in patients without concomitant risk factors. An analysis of 144 published articles describing TdP associated with noncardiac drugs revealed that 100% of the patients had at least 1 risk factor, and 71% had at least 2 risk factors.[193]
- Both common and rare genetic variants have been shown to increase the propensity to drug-induced QT interval prolongation.[194,195]

Aftermath

- Drug-induced TdP may result in morbidity that requires hospitalization and in mortality attributable to sudden cardiac death in ≤31% of patients.[175,196]

- Patients with advanced HF with a history of drug-induced TdP had a significantly higher risk of sudden cardiac death during therapy with amiodarone than amiodarone-treated patients with no history of drug-induced TdP (55% versus 15%).[197]
- Current use of antipsychotic drugs was associated with a significant increase in the risk of sudden cardiac death attributable to TdP (OR, 3.3; 95% CI, 1.8–6.2).[198]
- In a cohort of 459 614 Medicaid and Medicaid-Medicare enrollees aged 30 to 75 years who were taking antipsychotic medications, the incidence of sudden death or ventricular arrhythmia was 3.4 per 1000 person-years.[199]
- Hospitalization was required in 47% and death occurred in 8% of patients with QT-interval prolongation and TdP caused by administration of methadone.[200]

Prevention

- Keys to reducing the incidence of drug-induced cardiac arrhythmias include increased awareness among the medical, pharmaceutical, and nursing professions of the potential problems associated with the use of certain agents.
- Appropriate monitoring when a QT-interval–prolonging drug is administered is essential. Also, prompt withdrawal of the offending agent should be initiated.[201]

Table 16-1. Cumulative Incidence Rate (%) Over 5 Years After AF Diagnosis by Age

Age Group, y	Mortality	Heart Failure	Myocardial Infarction	Stroke	Gastrointestinal Bleeding
67–69	28.8	11.0	3.3	5.0	4.4
70–74	32.3	12.1	3.6	5.7	4.9
75–79	40.1	13.3	3.9	6.9	5.9
80–84	52.1	15.1	4.3	8.1	6.4
85–89	67.0	15.8	4.4	8.9	6.6
≥90	84.3	13.7	3.6	6.9	5.4

AF indicates atrial fibrillation.
Data derived from Piccini et al[149] by permission of the European Society of Cardiology.

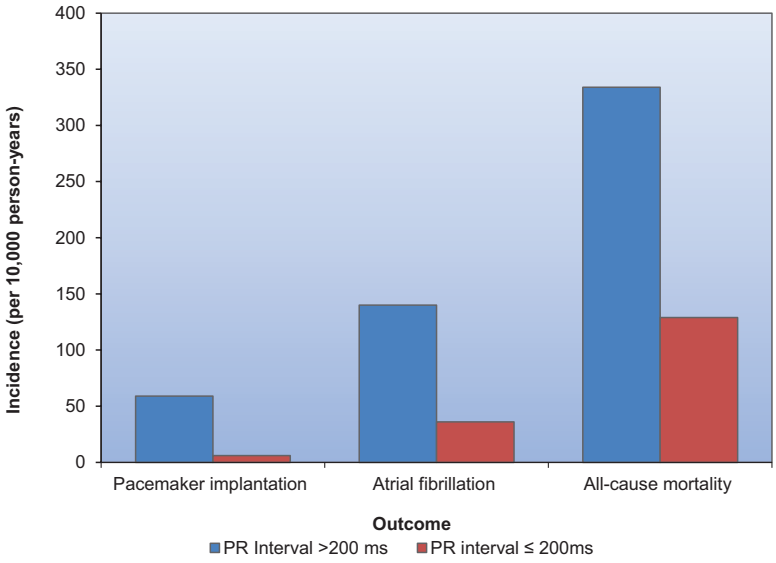

Chart 16-1. Long-term outcomes in individuals with prolonged PR interval (>200 ms; first-degree atrioventricular block) compared with individuals with normal PR interval in the Framingham Heart Study. Data derived from Cheng et al.[15]

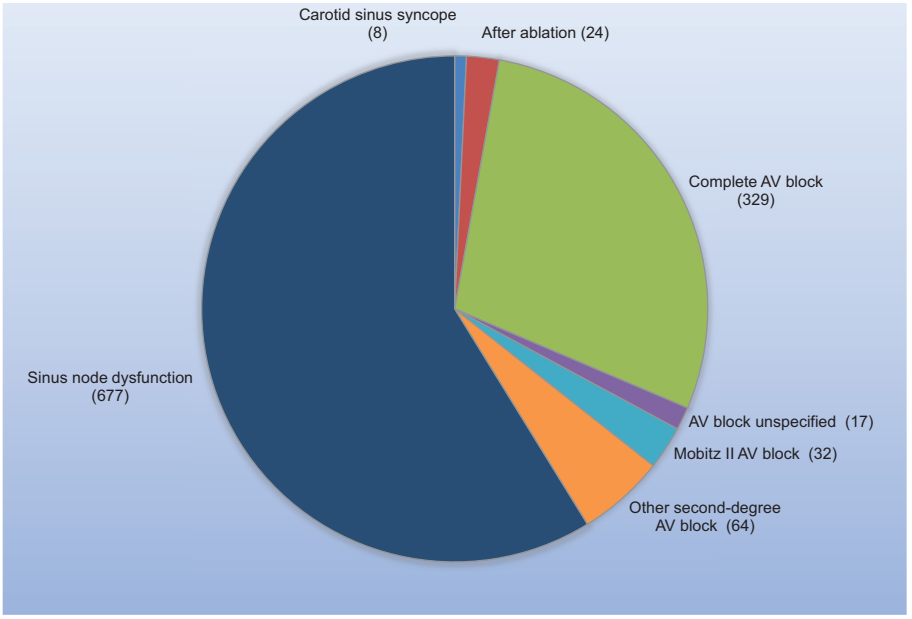

Chart 16-2. Primary indications (in thousands) for pacemaker placement between 1990 and 2002 from the National Hospital Discharge Survey. AV indicates atrioventricular. Data derived from Birnie et al.[37]

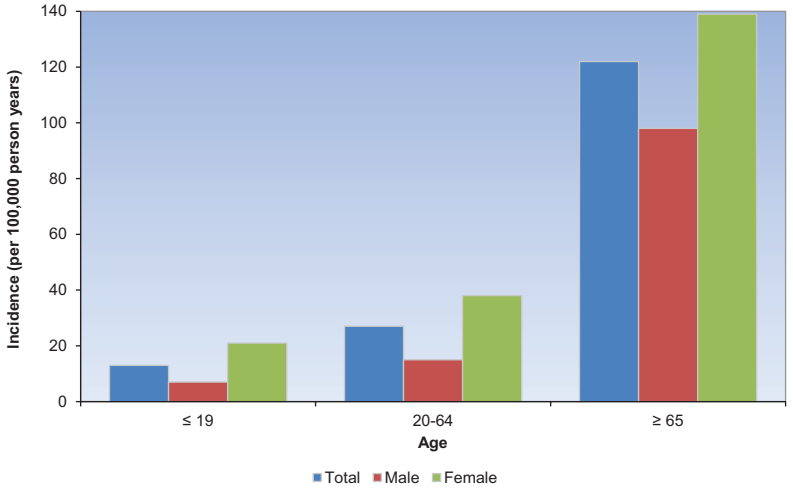

Chart 16-3. Incidence rate of paroxysmal supraventricular tachycardia per 100 000 person-years by age and sex. Data derived from Orejarena et al.[39]

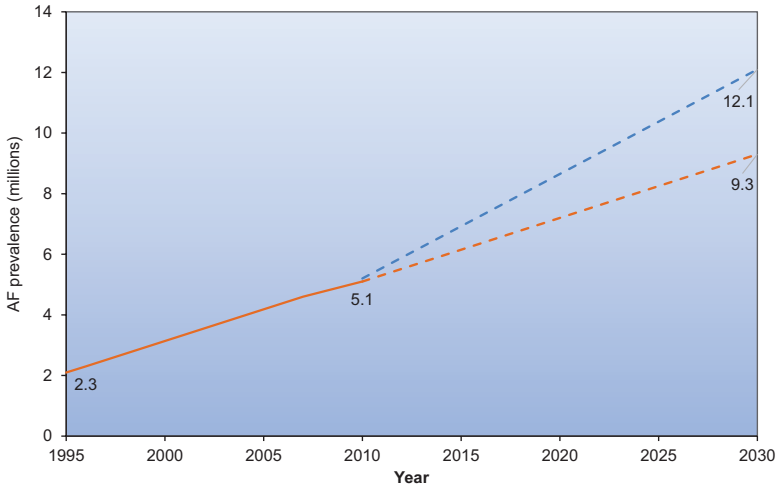

Chart 16-4. Current and future US prevalence projections for atrial fibrillation (AF). Projections assume no increase (red dashed line) or logarithmic growth (blue dashed line) in incidence of AF from 2007. Data derived from Go et al[75] and modified from Colilla et al.[77]

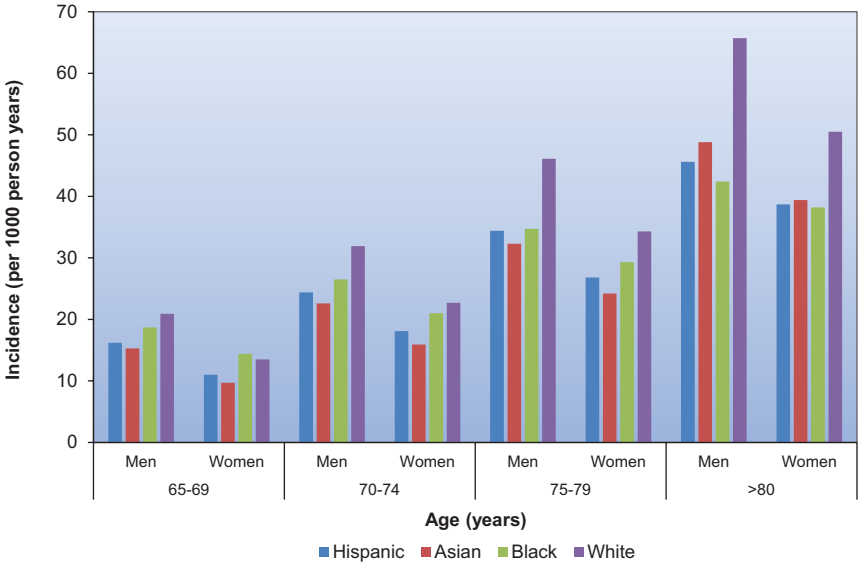

Chart 16-5. Atrial fibrillation incidence by race. Incidence increases with age among different races and sexes in the United States. Data derived from Dewland et al.[81]

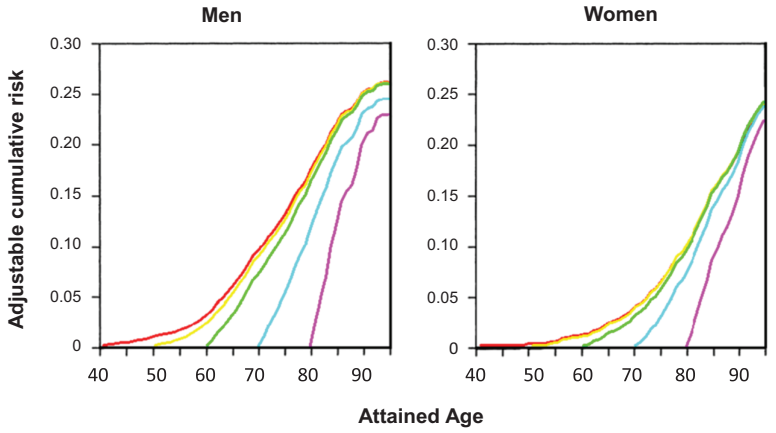

Chart 16-6. Lifetime cumulative risk for atrial fibrillation (AF) at different ages (through age 94 years) by sex. With increasing incidence of AF with aging, lifetime risk is unchanged. Reprinted from Lloyd-Jones et al with permission.[102] Copyright © 2004, American Heart Association, Inc.

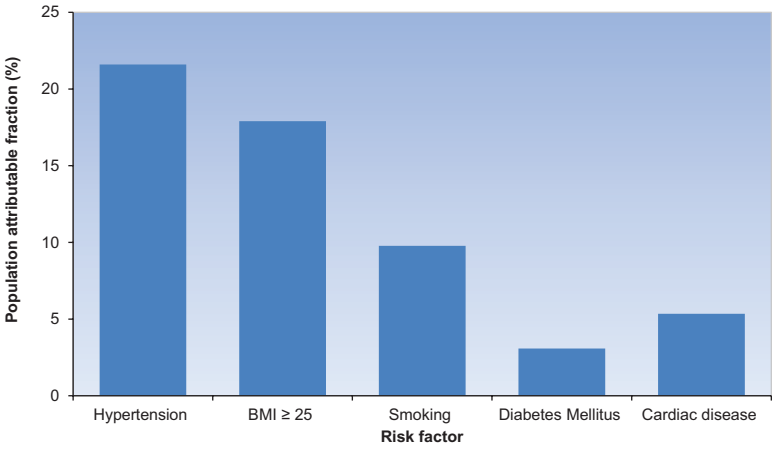

Chart 16-7. Population attributable fraction of major risk factors for atrial fibrillation in the Atherosclerosis Risk in Communities study. BMI indicates body mass index (in kg/m^2); cardiac disease, patients with history of coronary artery disease or heart failure; and smoking, current smoker. Data derived from Huxley et al.[126]

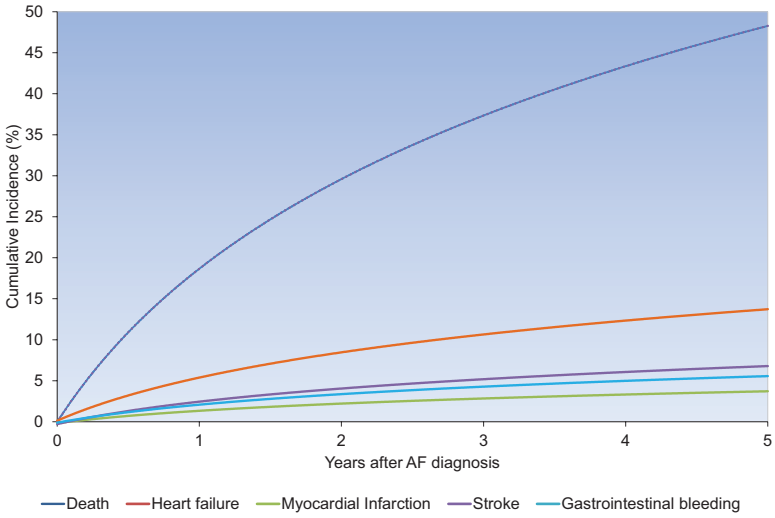

Chart 16-8. Cumulative incidence of events in the 5 years after diagnosis of incident atrial fibrillation (AF) in Medicare patients. Reprinted from Piccini et al.[149] Copyright © 2014, European Society of Cardiology.

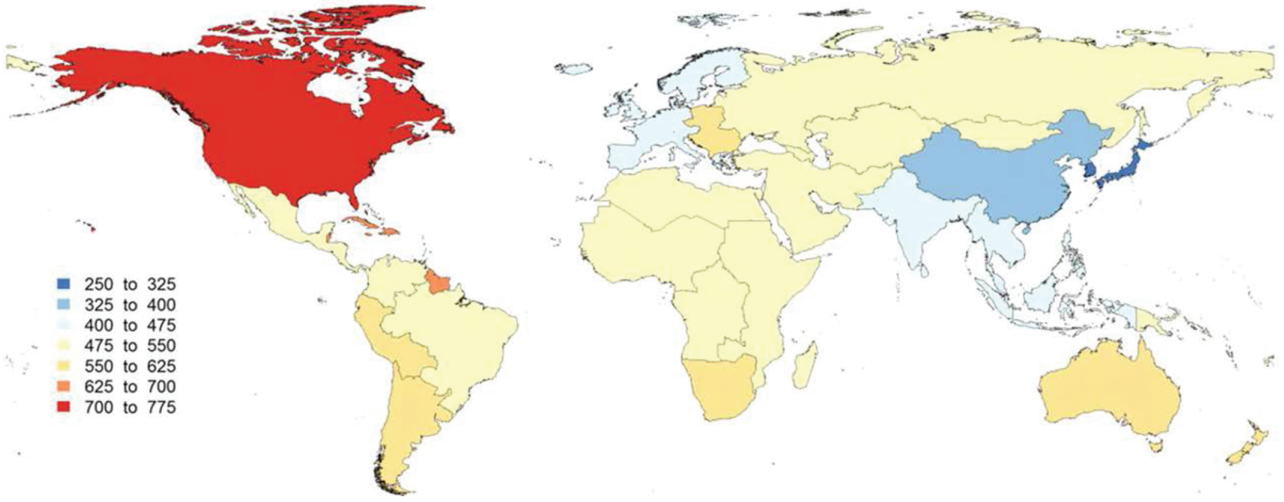

Chart 16-9. Atrial fibrillation (AF) cost estimates, where AF is the primary diagnosis in inpatient and outpatient encounters. Indirect costs are incremental costs of inpatient and outpatient visits. USD indicates US dollars. Data derived from Kim et al[157] and Coyne et al.[202]

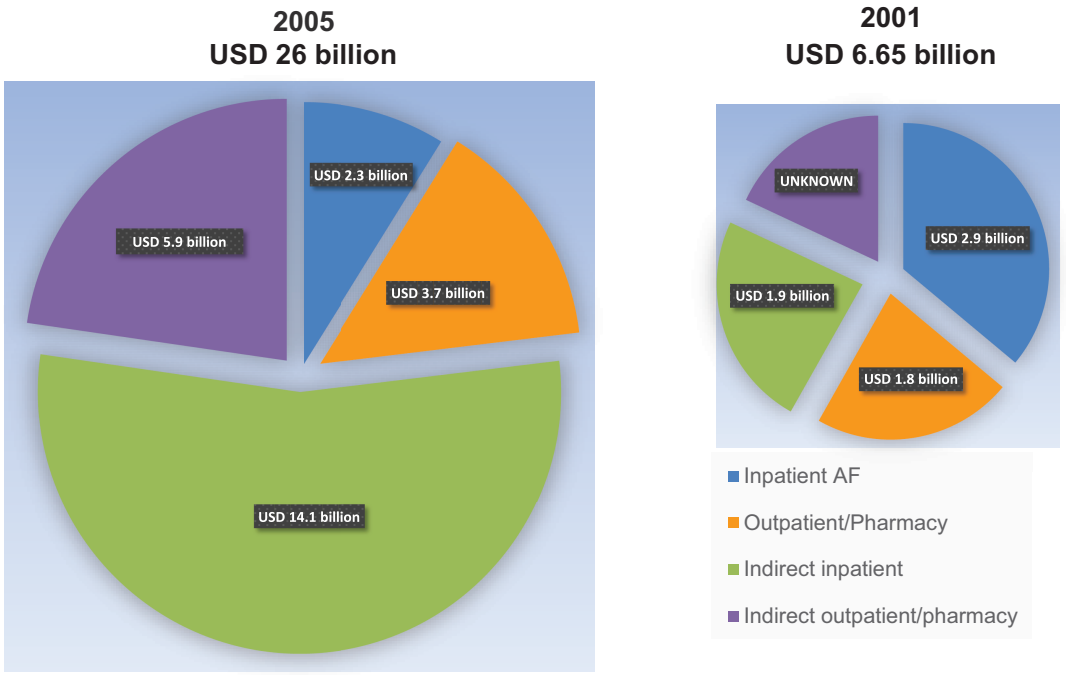

Chart 16-10. Global age-adjusted atrial fibrillation prevalence rates (per 100 000 population) in the 2010 Global Burden of Disease Study. Reprinted from Chugh et al with permission.[160] Copyright © 2014, American Heart Association, Inc.

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17. Sudden Cardiac Arrest

See Tables 17-1 through 17-3 and Charts 17-1 through 17-3.

Cardiac Arrest (Including VF and Ventricular Flutter)

ICD-9 427.4, 427.5; ICD-10 I46.0, I46.1, I46.9, I49.0

Mortality—16 415. Any-mention mortality—352 089.

Cardiac arrest is defined as the cessation of cardiac mechanical activity, as confirmed by the absence of signs of circulation.[1] Cardiac arrest is traditionally categorized as being of cardiac or noncardiac origin. An arrest is presumed to be of cardiac origin unless it is known or likely to have been caused by trauma, submersion, drug overdose, asphyxia, exsanguination, or any other noncardiac cause as best determined by rescuers.[1] In practice, the accuracy of this classification is difficult, and some data sets do not attempt to make the distinction. Because of fundamental differences in underlying causes and the system of care, epidemiological data for OHCA and IHCA are typically collected and reported separately. For similar reasons, data for adults and children (aged 1–18 years) are commonly reported separately.

There are a number of ongoing challenges to understanding the epidemiology of cardiac arrest in the United States. Despite being a leading cause of death, there are currently no nationwide standards for surveillance to monitor the incidence and outcomes of cardiac arrest. In addition, it is challenging to define what is "unexpected" or "sudden" death. Sudden cardiac death has been defined as unexpected death without an obvious noncardiac cause that occurs within 1 hour of symptom onset (witnessed) or within 24 hours of last being observed in normal health (unwitnessed)[2]; however, this definition is difficult to apply in the real-world setting. OHCA registries and clinical trials typically include patients in cardiac arrest who were either assessed by EMS providers or treated by EMS providers. Regional and cultural differences in EMS system access and decision to treat are potential sources of variability in these data sets. Similar challenges exist related to the epidemiology of IHCA.

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Abbreviations Used in Chapter 17

AED	automated external defibrillator
AF	atrial fibrillation
AV	atrioventricular
BMI	body mass index
BP	blood pressure
CAD	coronary artery disease
CARDIA	Coronary Artery Risk Development in Young Adults
CARES	Cardiac Arrest Registry to Enhance Survival
CI	confidence interval
CPR	cardiopulmonary resuscitation
DCM	dilated cardiomyopathy
ECG	electrocardiogram
EMS	emergency medical services
GWTG	Get With The Guidelines
HCM	hypertrophic cardiomyopathy
HD	heart disease
HF	heart failure
HR	hazard ratio
ICD-9	*International Classification of Diseases, 9th Revision*
ICD-10	*International Classification of Diseases, 10th Revision*
IHCA	in-hospital cardiac arrest
LCL	lower confidence limit
LQTS	long-QT syndrome
LV	left ventricular
MI	myocardial infarction
OHCA	out-of-hospital cardiac arrest
OR	odds ratio
PA	physical activity
PAR	population attributable risk
PVT	polymorphic ventricular tachycardia
ROC	Resuscitation Outcomes Consortium
RR	relative risk
SD	standard deviation
UCL	upper confidence limit
VF	ventricular fibrillation
VT	ventricular tachycardia

Out-of-Hospital Cardiac Arrest

For additional details on OHCA treatment, please refer to Chapter 23, Quality of Care, Tables 23-8 and 23-9.

There are wide variations in the reported incidence of and outcomes for OHCA. These differences are caused in part by differences in definition and ascertainment of cardiac arrest data, as well as differences in treatment after the onset of cardiac arrest.

Children

(See Table 17-1 and Chart 17-1.)

Incidence and Risk Factors

- The incidence of OHCA among individuals <18 years of age in the United States is best characterized by data from the ROC Registry. Extrapolation of the incidence of EMS-assessed OHCA reported by ROC (ROC Investigators, unpublished data, November 23, 2015) suggests that each year, 7037 (quasi CI, 6214–7861) children experience EMS-assessed OHCA in the United States.
- The underlying cause of pediatric OHCA varies by age group. Chart 17-1 illustrates the causes of OHCA by age group based on a retrospective cohort of pediatric OHCA patients treated in King County, WA, between 1980 and 2009.[2]
- The incidence of sudden cardiac death in high school athletes screened every 3 years between 1993 and 2012 with standard preparticipation evaluations during Minnesota State High School League activities was 0.24 per 100 000 athlete-years.[3]
- A longitudinal study of students 17 to 24 years of age participating in National Collegiate Athletic Association sports showed that the incidence of nontraumatic OHCA was 1 per 22 903 athlete participant-years. The incidence

of cardiac arrest tended to be higher among blacks than among whites and among men than among women.[4]
- The most common causes of sudden death in competitive young athletes are hypertrophic cardiomyopathy (26%), commotio cordis (20%), and coronary artery anomalies (14%).[5]

Aftermath

- In the ROC Epistry, survival to hospital discharge in 2014 after EMS-treated nontraumatic cardiac arrest with any first recorded rhythm was 7.2% (95% CI, 4.3%–10.2%) for children (ROC Investigators, unpublished data, June 4, 2015). Survival after bystander-witnessed VF was 71.4% (95% CI, 38.0%–100.0%) for children (ROC Investigators, unpublished data, November 23, 2015).
- In 1 case series, long-term survival of pediatric OHCA patients surviving to hospital discharge was 92% at 1 year, 86% at 5 years, and 77% at 20 years.[6]

Adults

Incidence

(See Tables 17-1 and 17-2 and Charts 17-2 and 17-3.)

- The incidence of EMS-assessed, EMS-treated nontraumatic cardiac arrest and bystander-witnessed VF among individuals of any age during 2014 in the United States is best characterized by an ongoing registry from ROC.
- The total resident population of the United States was 321 716 000 as of September 10, 2015.[7] Extrapolation of the incidence of EMS-assessed OHCA reported by the ROC Investigators (ROC Investigators, unpublished data, November 23, 2015) to the total population of the United States suggests that each year, 110.8 individuals per 100 000 population (95% CI, 108.9–112.6), or 356 500 people of any age (quasi-CI, 350 000–362 000) or 347 000 adults (95% CI, 341 000–353 000), experience EMS-assessed OHCA.
- On the basis of extrapolation of data from the Oregon Sudden Unexpected Death Study, the estimated risk-adjusted incidence of sudden cardiac arrest was 76 per 100 000 per year (≈230 000 per year in the United States) and the estimated risk-adjusted incidence of sudden cardiac death was 69 per 100 000 per year (≈210 000 per year in the United States).[8] This data set excluded cases that were judged to have a noncardiac cause of arrest, which underestimates the overall burden of cardiac arrest. In the same study, the estimated societal burden of premature death was 2 million years of potential life lost for men and 1.3 million years of potential life lost for women.
- Approximately 60% of OHCAs are treated by EMS personnel.[9]
- Twenty-five percent of those with EMS-treated OHCA have no symptoms before the onset of arrest.[10]
- Among EMS-treated patients with OHCA, 23% have an initial rhythm of VF or VT or have a rhythm that is shockable by an automated external defibrillator.[11]
- The incidence of cardiac arrest with an initial rhythm of VF is decreasing over time; however, the incidence of cardiac arrest with any initial rhythm is not decreasing.[12]
- The median age for OHCA is 65 years.[13]
- Cardiac arrest is witnessed by a bystander in 38% of cases and by an EMS provider in 12% of cases and is unwitnessed in 50% of cases.[13]
- The majority of OHCAs occur at a home or residence (70%).[13]
- Among 10.9 million registered participants in 40 marathons and 19 half marathons, the overall incidence of cardiac arrest was 0.54 per 100 000 participants (95% CI, 0.41–0.70).[14] Those with cardiac arrest were more often male and were running a marathon versus a half marathon. Seventy-one percent of those with cardiac arrest died; those who died were younger (mean 39±9 years of age) than those who did not die (mean 49±10 years of age), were more often male, and were more often running a full marathon.

Risk Factors

- Prior HD is a major risk factor for cardiac arrest. A study of 1275 health maintenance organization enrollees 50 to 79 years of age who had cardiac arrest showed that the incidence of OHCA was 6.0 per 1000 person-years in subjects with any clinically recognized HD compared with 0.8 per 1000 person-years in subjects without HD. In subgroups with HD, incidence was 13.6 per 1000 person-years in subjects with prior MI and 21.9 per 1000 person-years in subjects with HF.[15]
- A family history of cardiac arrest in a first-degree relative is associated with an ≈2-fold increase in risk of cardiac arrest.[4,16]
- In a study of 81 722 women in the Nurses' Health Study, the PAR of sudden death associated with 4 lifestyle factors (smoking, PA, diet, and weight) was 81% (95% CI, 52%–93%).[17]
- A study conducted in New York City found the age-adjusted incidence of OHCA per 10 000 adults was 10.1 among blacks, 6.5 among Hispanics, and 5.8 among whites.[18]
- Analysis of 9235 sudden cardiac arrests in the ROC Epistry revealed the incidence of sudden cardiac arrest in the lowest socioeconomic quartile was nearly double that in the highest quartile (incidence rate ratio, 1.9; 95% CI, 1.8–2.0).[19]
- Analysis of data from the CARES registry revealed that patients who had a cardiac arrest in low-income black neighborhoods were less likely to receive bystander-initiated CPR than those who had a cardiac arrest in high-income white neighborhoods (OR, 0.49; 95% CI, 0.41–0.58).[20]

Aftermath

(See Table 17-3 and Chart 17-3.)

- In the ROC Epistry, survival to hospital discharge in 2014 after nontraumatic EMS-treated cardiac arrest with any first recorded rhythm was 12.0% (95% CI, 11.3%–12.7%) for patients of any age (ROC Investigators, unpublished data, November 23, 2015). Survival after bystander-witnessed VF was 38.6% (95% CI, 35.4%–41.8%) for patients of any age. Contemporary survival data will be available on completion of ongoing randomized trials.
- In the ROC Epistry between 2006 and 2010, unadjusted survival to hospital discharge after EMS-treated OHCA increased from 8.2% in 2006 to 10.4% in 2010.[21]
- In CARES, risk-adjusted rates of OHCA survival to hospital discharge increased from 5.7% in 2005 to 2006 to 8.3% in 2012 (adjusted risk ratio, 1.47; 95% CI, 1.26–1.70; $P<0.001$).[22]
- In CARES, 45 501 OHCAs were treated in 2014. Survival to hospital discharge was 10.8%, and survival with good

neurological function (Cerebral Performance Category 1 or 2) was 8.5%. For bystander-witnessed arrest with a shockable rhythm, survival to hospital discharge was 36.1%.[13]

- In a study using the US Nationwide Inpatient Sample data, in-hospital mortality for patients hospitalized after treatment for cardiac arrest declined 11.8%, from 69.6% in 2001 to 57.8% in 2009.[23]
- A study conducted in New York City found the age-adjusted survival to 30 days after discharge was more than twice as poor for blacks as for whites, and survival among Hispanics was also lower than among whites.[18]
- A study in Denmark of 1218 OHCA patients between 2002 and 2010 demonstrated that transport to a non–tertiary care center versus a tertiary care center after return of spontaneous circulation or with ongoing resuscitation was independently associated with increased risk of death (HR, 1.32; 95% CI, 1.09–1.59; *P*=0.004).[24]

In-Hospital Cardiac Arrest

For additional details on in-hospital arrest treatment outcomes, please refer to Chapter 23, Quality of Care.

Children

Aftermath

- Among 1031 children at 12 hospitals in the GWTG-Resuscitation Registry between 2001 and 2009, the initial cardiac arrest rhythm was asystole and pulseless electrical activity in 874 children (84.8%) and VF and pulseless VT in 157 children (15.2%). Risk-adjusted rates of survival to discharge increased from 14.3% in 2000 to 43.4% in 2009 (adjusted rate ratio per year, 1.08; 95% CI, 1.01–1.16; *P* for trend=0.02) without an increased rate of neurological disability among survivors over time (unadjusted *P* for trend=0.32).[25]
- In 2014, the GWTG-Resuscitation Registry reported 566 IHCAs in children 0 to 18 years old, with 241 surviving to hospital discharge (43%; 95% CI, 39%–47%), and 438 IHCAs in neonates 0 to 30 days old, with 187 surviving to hospital discharge (43%; 95% CI, 38%–47%).

Adults

Incidence

- Extrapolation of the incidence of IHCA reported by GWTG-Resuscitation to the total population of hospitalized patients in the United States suggests that each year, 209 000 (quasi-CI, 192 000–211 000) people are treated for IHCA.[26]
- Analysis of the UK National Cardiac Arrest Audit database between 2011 and 2013 (144 acute hospitals and 22 628 patients ≥16 years of age) revealed an incidence of IHCA of 1.6 per 1000 hospital admissions, with a median across hospitals of 1.5 (interquartile range, 1.2–2.2). The overall unadjusted survival rate was 18.4%.[27]

Aftermath

- In 2014, the GWTG-Resuscitation Registry reported 20 873 IHCAs in adults ≥18 years old, with 5168 surviving to hospital discharge (24.8%; 95% CI, 24.2%–25.4%).
- In the UK National Cardiac Arrest Audit database between 2011 and 2013, the overall unadjusted survival rate was 18.4%. Survival was 49% when the initial rhythm was shockable and 10.5% when the initial rhythm was not shockable.[27]
- Chan et al[28] demonstrated that rates of survival to discharge were lower for black patients (25.2%) than for white patients (37.4%) after IHCA. Lower rates of survival to discharge for blacks reflected lower rates of both successful resuscitation (55.8% versus 67.4% for blacks versus whites, respectively) and postresuscitation survival (45.2% versus 55.5%, respectively). Adjustment for the hospital site at which patients received care explained a substantial portion of the racial differences in successful resuscitation (adjusted RR, 0.92; 95% CI, 0.88–0.96; *P*<0.001) and eliminated the racial differences in postresuscitation survival (adjusted RR, 0.99; 95% CI, 0.92–1.06; *P*=0.68).

Inherited Syndromes Associated With Sudden Cardiac Death

Overview

- The majority of OHCA occurs in the general population without an underlying inherited syndrome associated with sudden cardiac death.[29] A large proportion of patients with OHCA have coronary atherosclerosis.[30] Recent data described below aid in the identification of high-risk subsets that contribute to a small proportion of the overall burden of OHCA but significantly increase the risk of affected individuals experiencing OHCA.

Long-QT Syndrome

- The hereditary LQTS is a genetic channelopathy characterized by prolongation of the QT interval (typically >460 ms) and susceptibility to ventricular tachyarrhythmias that lead to syncope and sudden cardiac death. Investigators have identified mutations in 13 genes leading to this phenotype (*LQT1* through *LQT13*). *LQT1* (*KCNQ1*), *LQT2* (*KCNH2*), and *LQT3* (*SCN5A*) mutations account for the majority (≈80%) of the typed mutations.[31,32]
- Prevalence of LQTS is estimated at 1 per 2000 live births from ECG-guided molecular screening of ≈44 000 infants (mostly white) born in Italy.[33] A similar prevalence was found among nearly 8000 Japanese school children screened by use of an ECG-guided molecular screening approach.[34] LQTS has been reported among those of African descent, but its prevalence is not well assessed.[35]
- There is variable penetrance and a sex-time interaction for LQTS symptoms. Risk of cardiac events is higher among boys than girls (21% among boys and 14% among girls by 12 years of age). Risk of events during adolescence is equivalent between sexes (≈25% for both sexes from ages 12–18 years). Conversely, risk of cardiac events in young adulthood is higher among women than men (39% among women from ages 18–40 years and 16% among men).[32]
- The mainstay of therapy and prevention is β-blockade treatment.[36,37] Implantable defibrillators are considered for high-risk individuals.[38]
- Individuals may be risk stratified for increased risk of sudden cardiac death[39] according to their specific long-QT mutation and their response to β-blockers.[37]

- Among 403 patients from the LQTS Registry from birth through age 40 years, multivariate analysis demonstrated that patients with multiple LQTS gene mutations had a 2.3-fold (P=0.015) increased risk for life-threatening cardiac events (comprising aborted cardiac arrest, implantable defibrillator shock, or sudden cardiac death) compared with patients with a single mutation.[40]

Short-QT Syndrome

- Short-QT syndrome is a recently described inherited mendelian condition characterized by shortening of the QT interval (typically QT <320 ms) and predisposition to AF, ventricular tachyarrhythmias, and sudden death. Mutations in 5 ion channel genes have been described (SQT1–SQT5).[41]
- In a population of 41 767 young, predominantly male Swiss transcripts, 0.02% of the population had a QT interval shorter than 320 ms.[42]
- Among 53 patients from the European Short QT Syndrome Registry (75% males, median age 26 years),[43] a familial or personal history of cardiac arrest was present in 89%. Twenty-four patients received an implantable cardioverter-defibrillator, and 12 received long-term prophylaxis with hydroquinidine. During a median follow-up of 64 months, 2 patients received an appropriate implantable cardioverter-defibrillator shock, and 1 patient experienced syncope. Nonsustained PVT was recorded in 3 patients.[43]
- In a cohort of 25 patients with short-QT syndrome ≤21 years of age followed up for 5.9 years, 6 patients had aborted sudden death (24%).[44] Sixteen patients (84%) had a familial or personal history of cardiac arrest. A gene mutation associated with short-QT syndrome was identified in 5 of 21 probands (24%).

Brugada Syndrome

- The Brugada syndrome is an acquired or inherited channelopathy characterized by persistent ST-segment elevation in the precordial leads (V_1–V_3), right bundle-branch block, and susceptibility to ventricular arrhythmias and sudden cardiac death.[45]
- Brugada syndrome is associated with mutations in several ion channel–related genes.[45]
- Prevalence is estimated at 1 to 5 per 10 000 individuals. Prevalence is higher in Southeast Asian countries, including Thailand and the Philippines. There is a strong male predominance (80% male).[45–50]
- Cardiac event rates for Brugada syndrome patients followed up prospectively in northern Europe (31.9 months) and Japan (48.7 months) were similar: 8% to 10% in patients with prior aborted sudden death, 1% to 2% in those with history of syncope, and 0.5% in asymptomatic patients.[51,52] Predictors of poor outcome included family history of sudden death and early repolarization pattern on ECG.[53,54]
- Among patients with spontaneous or drug-induced Brugada syndrome, first-degree AV block, syncope, and spontaneous type 1 ST-segment elevation were independently associated with risk of sudden death or implantable cardioverter-defibrillator–appropriate therapies.[55]

Catecholaminergic PVT

- Catecholaminergic PVT is a familial condition characterized by adrenergically induced ventricular arrhythmias associated with syncope and sudden death. It is associated with frequent ectopy, bidirectional VT, and PVT with exercise or catecholaminergic stimulation (such as emotion, or medicines such as isoproterenol).
- Mutations in genes encoding *RYR2*[57,57] are found in the majority, and mutations in genes encoding *CASQ2*[58,59] are found in a small minority.[51] However, a substantial proportion of individuals with catecholaminergic PVT do not have an identified mutation.
- Statistics regarding catecholaminergic PVT are primarily from case series. Of 101 patients with catecholaminergic PVT, the majority had experienced symptoms before 21 years of age.[51]
- In small series (n=27 to n=101) of patients followed up over a mean of 6.8 to 7.9 years, 27% to 62% experienced cardiac symptoms, and fatal or near-fatal events occurred in 13% to 31%.[51,52,56]
- Risk factors for cardiac events included younger age at diagnosis and absence of β-blocker therapy. A history of aborted cardiac arrest and absence of β-blocker therapy were risk factors for fatal or near-fatal events.[51]

Arrhythmogenic Right Ventricular Cardiomyopathy

- Arrhythmogenic right ventricular cardiomyopathy is a form of genetically inherited structural HD that presents with fibrofatty replacement of the myocardium, with clinical presentation of palpitations, syncope, and sudden death.[57]
- Twelve arrhythmogenic right ventricular cardiomyopathy loci have been described (ARVC1–ARVC12). Disease-causing genes for 8 of these loci have been identified, the majority of which are in desmosomally related proteins.[57]
- Prevalence is estimated at 2 to 10 per 10 000 individuals.[60,61] Of 100 patients reported on from the Johns Hopkins Arrhythmogenic Right Ventricular Dysplasia Registry, 51 were men and 95 were white, with the rest being of black, Hispanic, or Middle Eastern origin. Twenty-two percent of index cases had evidence of the familial form of arrhythmogenic right ventricular cardiomyopathy.[58]
- The most common presenting symptoms were palpitations (27%), syncope (26%), and sudden cardiac death (23%).[58]
- During a median follow-up of 6 years, 47 patients received an implantable cardioverter-defibrillator, 29 of whom received appropriate implantable cardioverter-defibrillator shocks. At the end of follow-up, 66 patients were alive. Twenty-three patients died at study entry, and 11 died during follow-up (91% of deaths were attributable to sudden cardiac arrest).[58] Similarly, the annual mortality rate was 2.3% for 130 patients with arrhythmogenic right ventricular cardiomyopathy from Paris, France, who were followed up for a mean of 8.1 years.[59]

Hypertrophic Cardiomyopathy

(Please refer to Chapter 20, Cardiomyopathy and Heart Failure, for statistics regarding the general epidemiology of HCM.)

- Over a mean follow-up of 8±7 years, 6% of HCM patients experienced sudden cardiac death.[62]

- Among 1866 sudden deaths in athletes between 1980 and 2006, HCM was the most common cause of cardiovascular sudden death (in 251 cases, or 36% of the 690 deaths that could be reliably attributed to a cardiovascular cause).[16]
- The risk of sudden death increases with increasing maximum LV wall thickness,[63,64] and the risk for those with wall thickness ≥30 mm is 18.2 per 1000 patient-years (95% CI, 7.3–37.6),[63] or approximately twice that of those with maximal wall thickness <30 mm.[63,64] Of note, an association between maximum wall thickness and sudden death has not been found in every HCM population.[63]
- Nonsustained VT is a risk factor for sudden death,[61,65] particularly in younger patients. Nonsustained VT in those ≤30 years of age is associated with a 4.35-greater odds of sudden death (95% CI, 1.5–12.3).[61]
- A history of syncope is also a risk factor for sudden death in these patients,[66] particularly if the syncope was recent before the initial evaluation and not attributable to a neurally mediated event.[67]
- The presence of LV outflow tract obstruction ≥30 mm Hg appears to increase the risk of sudden death by ≈2-fold.[68,69] The presence of LV outflow tract obstruction has a low positive predictive value (7%–8%) but a high negative predictive value (92%–95%) for predicting sudden death.[68,70]
- The rate of malignant ventricular arrhythmias detected by implantable cardioverter-defibrillators appears to be similar between those with a family history of sudden death in ≥1 first-degree relative and those with at least 1 of the risk factors described above.[71]
- The risk of sudden death increases with the number of risk factors.[72]

Early Repolarization Syndrome

(See Table 17-1.)

- Early repolarization, observed in ≈4% to 19% of the population[73–76] (more commonly in young men[73,75,77] and in athletes[74]) has conventionally been considered a benign finding.
- A clinically relevant syndrome was initially described in which ≥1-mm positive deflections (sometimes referred to as "J waves") in the S wave of ≥2 consecutive inferior or lateral leads was significantly more common among patients with idiopathic VF than among control subjects.[73,74] Given an estimated risk of idiopathic VF in the general population (among those aged 35–45 years) of 3.4 per 100 000, the positive predictive value of such J-wave findings in a person 35 to 45 years of age increases the chances of having idiopathic VF to 11 of 100 000.[74]
- In an analysis of the Social Insurance Institution's Coronary Disease Study in Finland, J-point elevation was identified in 5.8% of 10 864 people.[75] Those with inferior-lead J-point elevation more often were male and more often were smokers; had a lower resting heart rate, lower BMI, lower BP, shorter corrected QT interval, and longer QRS duration; and were more likely to have ECG evidence of CAD. Those with lateral J-point elevation were more likely to have LV hypertrophy. Before and after multivariable adjustment, subjects with J-point elevation ≥1 mm in the inferior leads (n=384) had a higher risk of cardiac death (adjusted RR, 1.28; 95% CI, 1.04–1.59; *P*=0.03) and arrhythmic death (adjusted RR, 1.43; 95% CI, 1.06–1.94; *P*=0.03); however, these patients did not have a significantly higher rate of all-cause mortality. Before and after multivariable adjustment, subjects with J-point elevation >2 mm (n=36) had an increased risk of cardiac death (adjusted RR, 2.98; 95% CI, 1.85–4.92; *P*=0.03), arrhythmic death (adjusted RR, 3.94; 95% CI, 1.96–7.90; *P*=0.03), and death of any cause (adjusted RR, 1.54; 95% CI, 1.06–2.24; *P*=0.03).
- In CARDIA, 18.6% of 5069 participants had early repolarization restricted to the inferior and lateral leads at baseline; by year 20, only 4.8% exhibited an early repolarization pattern.[76] Younger age, black race, male sex, longer exercise duration and QRS duration, and lower BMI, heart rate, QT index, and Cornell voltage were associated cross-sectionally with the presence of baseline early repolarization. Predictors of maintenance of the ECG pattern from baseline to year 20 were black race (OR, 2.62; 95% CI, 1.61–4.25), BMI (OR, 0.62 per 1 SD; 95% CI, 0.40–0.94), serum triglyceride levels (OR, 0.66 per 1 SD; 95% CI, 0.45–0.98), and QRS duration (OR, 1.68 per 1 SD; 95% CI, 1.37–2.06) at baseline.
- Evidence from families with a high penetrance of the early repolarization syndrome associated with a high risk of sudden death suggests that the syndrome can be inherited in an autosomal dominant fashion.[78] A meta-analysis of genome-wide association studies performed in population-based cohorts failed to identify any genetic variants that met criteria for statistical significance.[79]

Genome-Wide Association Studies

- Genome-wide association studies have been performed directly on cases of arrhythmic death to try to identify novel genetic variants associated with risk of sudden death. These are intended to discover previously unidentified genetic variants and biological pathways that contribute to potentially lethal ventricular arrhythmias. Limitations of these studies are the small number of samples available for analysis and the heterogeneity of case definition. The number of loci identified as having genome-wide significance for sudden cardiac death is much smaller than for other complex diseases. In addition, studies to date have not consistently identified the same variants. A pooled analysis of case-control and cohort studies used genome-wide association studies to identify a rare (1.4% minor allele frequency) novel marker at the BAZ2B locus (bromodomain adjacent zinc finger domain 2B) that was strongly associated with a risk of arrhythmic death (OR, 1.9; 95% CI, 1.6–2.3).[80]

Table 17-1. Incidence of Out-of-Hospital Cardiac Arrest in US Sites of the Resuscitation Outcomes Consortium

		Annual No. of US Cases		
	Incidence per 100 000 (95% CI)	n	95% LCL	95% UCL
EMS assessed				
Any age	110.8 (108.9–112.6)	356 461	350 349	362 252
Adults	140.7 (138.3–143.1))	347 322	341 397	353 246
Children	9.4 (8.3–10.5)	7037	6214	7861
EMS treated				
Any age	57.3 (56.0–58.7)	184 343	180 161	188 847
Adults	73.0 (71.2–74.7)	180 202	175 759	184 399
Children	7.3 (6.3–8.3)	5465	4716	6214
VF*				
Any age	12.1 (11.5–12.7)	38 928	36 997	40 858
Adults	15.8 (15.0–16.6)	39 003	37 028	40 978
Children	0.5 (0.3–0.8)	374	225	599
Bystander-witnessed VF				
Any age	7.0 (6.5–7.5)	22 520	20 912	24 129
Adults	9.2 (8.6–9.8)	22 710	21 229	24 192
Children	0.3 (0.1–0.5)	225	75	374

Assumes total US population is 321 716 000.[7] CI indicates confidence interval; EMS, emergency medical services; LCL, lower confidence limit; UCL, upper confidence limit; and VF, ventricular fibrillation.

*The estimated number of annual VF cases of any age is less than the estimated number of cases in adults alone because of rounding and missing information about patient age.

Source: Resuscitation Outcomes Consortium Investigators, unpublished data, data time frame is June 1, 2014, to May 31, 2015. Population growth of 0.93% per year has now been added from the 2010 population. In 2013, 23.27% of population was <18 years of age. This is used for annual number of case estimates for adults and children.

Table 17-2. Range of Reported Estimates of Burden of Out-of-Hospital Cardiac Arrest in the United States[81]

Patient Population	Incidence per 100 000 Person-Years	Total Incidence per Year*
CARES		
EMS treated	57	179 877
ROC Epistry*		
EMS treated	63.8	201 690
EMS treated and untreated†	124.8	394 529

CARES indicates Cardiac Arrest Registry to Enhance Survival; EMS, emergency medical services; and ROC, Resuscitation Outcomes Consortium.

*ROC Epistry incidence counts all cardiac arrests (with cardiac and noncardiac pathogenesis), whereas CARES incidence includes cardiac arrest of presumed cardiac origin only.

†"Untreated" refers to cases that did not receive resuscitation treatment because patients were either dead on EMS arrival or had existing do-not-resuscitate orders.

Table 17-3. Survival After Out-of-Hospital Cardiac Arrest in US Sites of the Resuscitation Outcomes Consortium

	Survival to Discharge (95% CI), %
EMS assessed	
Any age	6.3 (5.9–6.7)
Adults	6.4 (6.0–6.8)
Children	7.2 (4.3–10.2)
Unknown age	0.5 (0.0–1.3)
EMS treated	
Any age	12.0 (11.3–12.7)
Adults	12.1 (11.3–12.8)
Children	9.8 (5.8–13.7)
Unknown age	6.7 (0.0–19.3)
VF	
Any age	32.6 (30.2–34.9)
Adults	32.5 (30.1–34.8)
Children	40.0 (15.2–64.8)
Bystander-witnessed VF	
Any age	38.6 (35.4-41.8)
Adults	38.2 (35.0–41.4)
Children	71.4 (38.0–100)

CI indicates confidence interval; EMS, emergency medical services; and VF, ventricular fibrillation.

Source: Resuscitation Outcomes Consortium, unpublished data, time frame: June 1, 2014, to May 31, 2015.

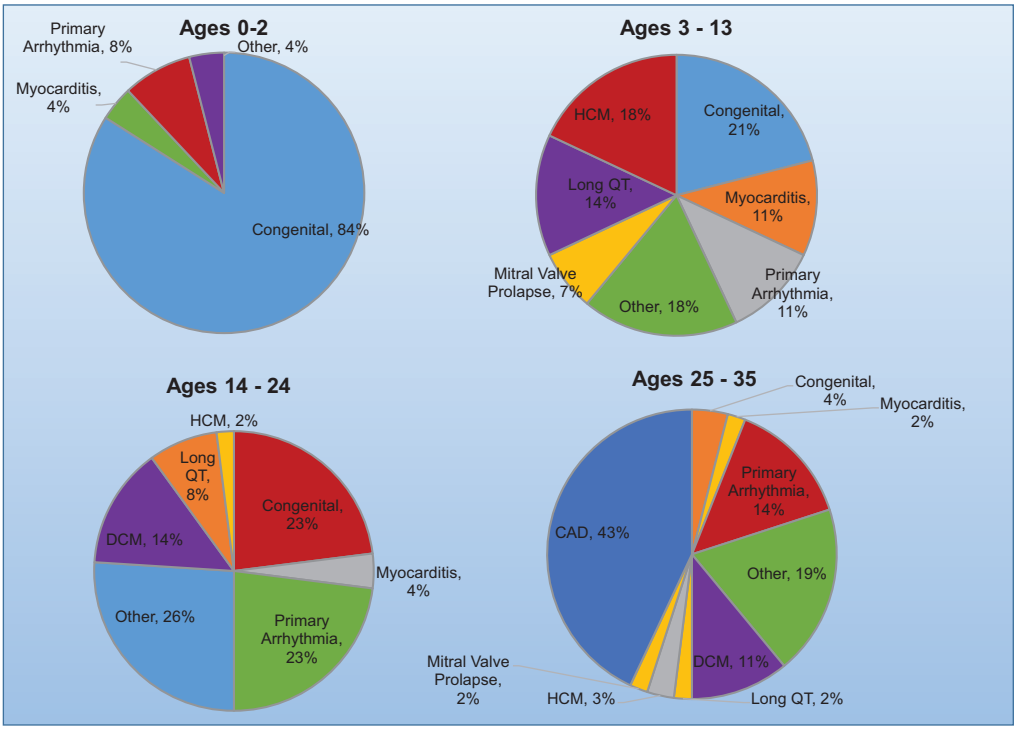

Chart 17-1. Detailed causes of arrest by age group. CAD indicates coronary artery disease; DCM, dilated cardiomyopathy; HCM, hypertrophic cardiomyopathy; and "Other," all other causes. Reprinted from Meyer et al with permission.[2] Copyright © 2012, American Heart Association, Inc.

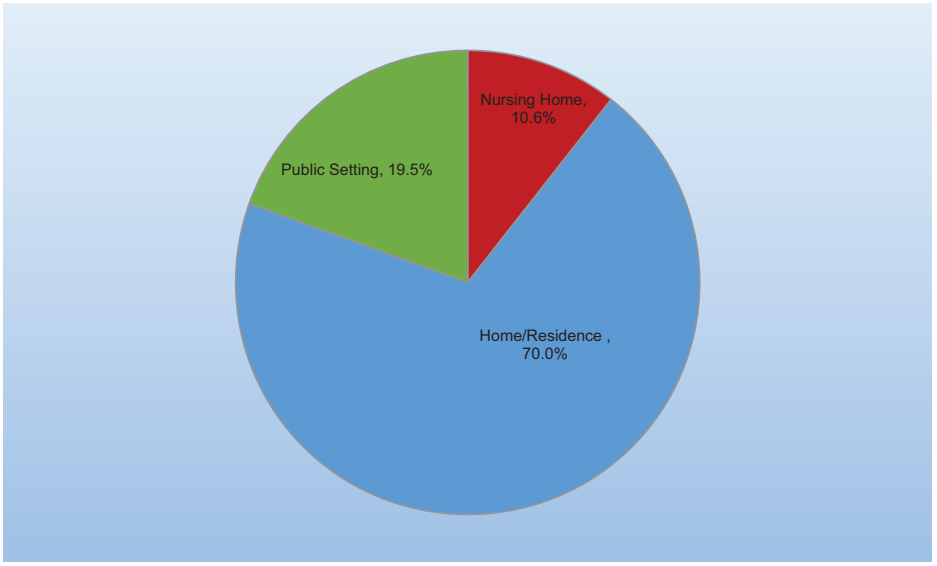

Chart 17-2. Location of out-of-hospital cardiac arrest, 2014. Data derived from 2014 Cardiac Arrest Registry to Enhance Survival (CARES) National Summary Report.[13]

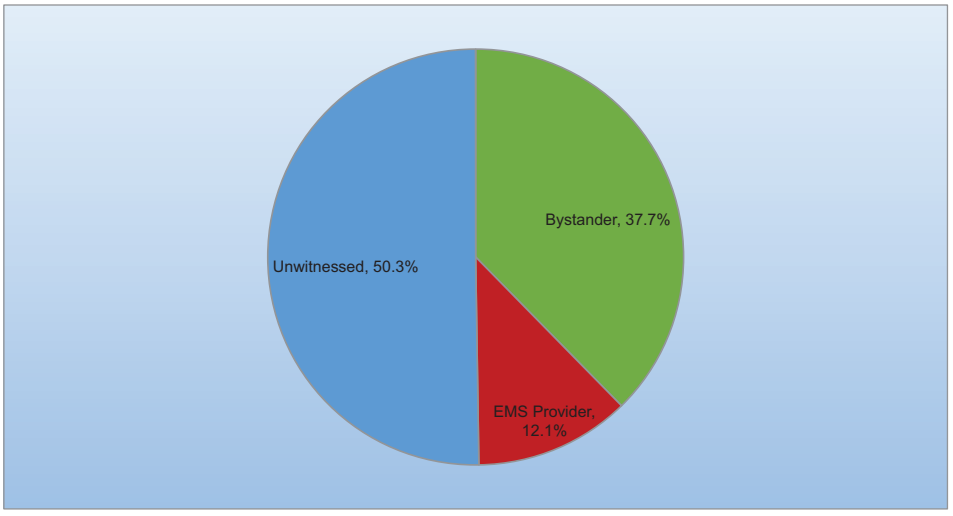

Chart 17-3. Out-of-hospital cardiac arrest witness status, 2014. EMS indicates emergency medical services. Data derived from 2014 Cardiac Arrest Registry to Enhance Survival (CARES) National Summary Report.[13]

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18. Subclinical Atherosclerosis

See Table 18-1 and Charts 18-1 through 18-7.

Atherosclerosis, a systemic disease process in which fatty deposits, inflammation, cells, and scar tissue build up within the walls of arteries, is the underlying cause of the majority of clinical cardiovascular events. Atherosclerosis can develop in large and small arteries supplying a variety of end-organs, including the heart, brain, kidneys, and extremities. There can be significant variability in which size arteries and locations are affected in individual patients, although atherosclerosis is often a systemic disease. In recent decades, advances in imaging technology have allowed for improved ability to detect and quantify atherosclerosis at all stages and in multiple different vascular beds. Early identification of subclinical atherosclerosis could lead to more aggressive lifestyle modifications and medical treatment to prevent clinical manifestations of atherosclerosis such as MI, stroke, or renal failure. Two modalities, CT of the chest for evaluation of CAC and B-mode ultrasound of the neck for evaluation of carotid artery IMT, have been used in large studies with outcomes data and may help define the burden of atherosclerosis in individuals before they develop clinical events such as heart attack or stroke. Another commonly used method for detecting and quantifying atherosclerosis in the peripheral arteries is the ABI. Data on cardiovascular outcomes are beginning to emerge for additional modalities that measure anatomic and functional measures of subclinical disease, including brachial artery reactivity testing, aortic and carotid magnetic resonance imaging, and tonometric methods of measuring vascular compliance or microvascular reactivity. Further research may help to define the role of these techniques in cardiovascular risk assessment. Some guidelines have recommended screening for subclinical atherosclerosis, especially by CAC, or IMT may be appropriate in people at intermediate risk for HD (eg, 10-year estimated risk of 10%–20%) but not for lower-risk general population screening or for people with preexisting HD or most other high-risk conditions.[1,2] However, a recent guideline notes those with DM who are ≥40 years of age may be suitable for screening of risk by coronary calcium.[1] According to the latest ACC/AHA cholesterol management guidelines, when treatment decisions are uncertain after 10-year risk is estimated, then the patient and clinician should take into consideration additional factors that modify the risk estimate, including an elevated CAC score or an ABI <0.9.[3] There are still limited data demonstrating whether screening with these and other imaging modalities can improve patient outcomes or whether it only increases downstream medical care costs. A recently published report in a large cohort randomly assigned to coronary calcium screening or not showed such screening to result in an improved risk factor profile without increasing downstream medical costs.[4] In addition, a recent cost-effectiveness analysis based on data from MESA[5] reported that CAC testing and statin treatment for those with CAC >0 was cost-effective (<$50 000 per quality-adjusted life-year) in intermediate-risk scenarios (CHD risk 5%–10%) considering less favorable statin assumptions ($1.00 per pill). Furthermore, a recent MESA analysis compared these

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Abbreviations Used in Chapter 18

ABI	ankle-brachial index
ACC	American College of Cardiology
AF	atrial fibrillation
AHA	American Heart Association
ARIC	Atherosclerosis Risk in Communities study
ATP III	Adult Treatment Panel III
BMI	body mass index
BP	blood pressure
CAC	coronary artery calcification
CAD	coronary artery disease
CARDIA	Coronary Artery Risk Development in Young Adults
CHD	coronary heart disease
CHS	Cardiovascular Health Study
CI	confidence interval
CONFIRM	Coronary CT Angiography Evaluation for Clinical Outcomes: An International Multicenter Registry
CRP	C-reactive protein
CT	computed tomography
CVD	cardiovascular disease
DBP	diastolic blood pressure
DM	diabetes mellitus
FHS	Framingham Heart Study
FMD	flow-mediated dilation
FRS	Framingham Risk Score
HBP	high blood pressure
HDL-C	high-density lipoprotein cholesterol
HD	heart disease
HF	heart failure
HR	hazard ratio
IMT	intima-media thickness
JUPITER	Justification for the Use of Statins in Primary Prevention: An Intervention Trial Evaluating Rosuvastatin
LDL-C	low-density lipoprotein cholesterol
MASALA	Mediators of Atherosclerosis in South Asians Living in America
MESA	Multi-Ethnic Study of Atherosclerosis
MI	myocardial infarction
NHLBI	National Heart, Lung, and Blood Institute
NNT_5	5-year number needed to treat
PAD	peripheral artery disease
RR	relative risk
SBP	systolic blood pressure
SD	standard deviation
TIA	transient ischemic attack
TIPS	The Indian Polycap Study

CAC-based treatment strategies to a "treat all" strategy and to treatment according to the ATP III guidelines, with clinical and economic outcomes modeled over both 5- and 10-year time horizons.[6] The results consistently demonstrated that it is both cost-saving and more effective to scan intermediate-risk patients for CAC and to treat those with CAC ≥1 than to use treatment based on established risk assessment guidelines.[6]

Coronary Artery Calcification

Background

- CAC is a measure of the burden of atherosclerosis in the heart arteries and is measured by CT. Other components of the atherosclerotic plaque, including fatty (eg, cholesterol-rich components) and fibrotic components, often accompany CAC and may be present even in the absence of CAC.
- The presence of any CAC, which indicates that at least some atherosclerotic plaque is present, is defined by an Agatston score >0. Clinically significant plaque, frequently an indication for more aggressive risk factor management, is often defined by an Agatston score ≥100 or a score ≥75th percentile for one's age and sex. However, although they predict short- to intermediate-term risk, absolute CAC cutoffs offer more prognostic information across all age groups in both men and women.[7] An Agatston score ≥400 has been noted to be an indication for further diagnostic evaluation (eg, exercise testing or myocardial perfusion imaging) for CAD.

Prevalence

(See Table 18-1 and Charts 18-1 and 18-3.)

- The NHLBI's FHS reported CAC measured in 3238 white adults in age groups ranging from <45 years of age to ≥75 years of age.[8]
  - —Overall, 32.0% of women and 52.9% of men had prevalent CAC.
  - —Among participants at intermediate risk according to FRS, 58% of women and 67% of men had prevalent CAC.
- The NHLBI's CARDIA study measured CAC in 3043 black and white adults 33 to 45 years of age (at the CARDIA year 15 examination).[9]
  - —Overall, 15.0% of men and 5.1% of women, 5.5% of those 33 to 39 years of age and 13.3% of those 40 to 45 years of age, had prevalent CAC. Overall, 1.6% of participants had an Agatston score that exceeded 100.
  - —Chart 18-1 shows the prevalence of CAC by ethnicity and sex. The prevalence of CAC was lower in black men than in white men but was similar in black and white women at these ages.
- The NHLBI's Jackson Heart Study recently reported outcomes with presence of elevated CAC (>100) in 4416 African American participants (mean age 54 years; 64% women) followed up for 6 years.[10]
  - —CAC >100 was noted in 14% of those without any metabolic syndrome or DM, 26% of those with metabolic syndrome, and 41% of those with DM.
  - —At 6-year follow-up, 265 CVD events were noted in this cohort.
  - —High CAC scores were significantly associated with CVD events among those with neither metabolic syndrome nor DM (HR, 4.3; 95% CI, 2.0–9.5), those with metabolic syndrome (HR, 2.2; 95% CI, 1.1–4.4), and those with DM (HR, 3.4; 95% CI, 1.6–8.7).
  - —In comparison, the presence of PAD was not predictive of CVD events in either group.
- The NHLBI's MESA measured CAC in 6814 participants 45 to 84 years of age, including white (n=2619), black (n=1898), Hispanic (n=1494), and Chinese (n=803) men and women.[11]
  - —Chart 18-2 shows the prevalence of CAC by sex and ethnicity.
  - —The prevalence and 75th percentile levels of CAC were highest in white men and lowest in black and Hispanic women. Significant ethnic differences persisted after adjustment for risk factors, with the RR of coronary calcium being 22% less in blacks, 15% less in Hispanics, and 8% less in Chinese than in whites.
  - —Table 18-1 shows the 75th percentile levels of CAC by sex and race at selected ages. These might be considered cut points above which more aggressive efforts to control risk factors (eg, elevated cholesterol or BP) could be implemented or at which treatment goals might be more aggressive (eg, LDL-C <100 mg/dL instead of <130 mg/dL).
- In a comparison of MESA with the MASALA study, which is a community-based cohort of South Asians in the United States (mean age 58 years), the age-adjusted prevalence of CAC was similar among white (68.8%) and South Asian (67.9%) men, with these groups having a greater prevalence of CAC than Chinese (57.8%), African-American (51.2%), and Hispanic (57.9%) men. In contrast, the age-adjusted prevalence of CAC was lower in South Asian women (36.8%) than in white women (42.6%) and women of other races/ethnicities.[12]
- The prevalence of CAC varies widely according to baseline risk profile, including global scores such as the FRS. In a report from MESA,[13] the prevalence of CAC among individuals with very low FRS (≤2.5%) was 22%, and it was 39% among those with FRS 2.5% to 5% 10-year risk. In recent studies from MESA, the prevalence of CAC in those with no lipid abnormalities was 42%,[14] and nearly one fifth (22%) of individuals in MESA with no known traditional CVD risk factors had presence of CAC.[15]
- In a recent update,[16] the 10-year trends in CAC among individuals without clinical CVD in MESA were reported. After adjustment for age, sex, ethnicity, and type of CT scanner, the proportion of participants with no CAC decreased over time from 40.7% to 32.6% (P=0.007), and the proportions increased from 29.9% to 37.0% (P=0.01) for those with a CAC score ranging from 1 to 99 and from 14.7% to 17.7% (P=0.14) for those with a CAC score of 100 to 299, whereas the proportion with a CAC score ≥400 decreased from 9.1% to 7.2% (P=0.11). Trends in CAC among the 4 race/ethnicity groups revealed a significant trend toward increased prevalence of CAC in African Americans but not in any other group. Among African Americans, the CAC prevalence ratio (year 10 versus baseline) was 1.27

(P<0.001 for test for trend). Adjustment for risk factors made no notable difference in CAC trends in any ethnic group.[16]

CAC and Incidence of Cardiovascular Events

(See Charts 18-4 and 18-5.)

- The NHLBI's MESA recently reported on the association of CAC scores with first CHD events over a median follow-up of 3.9 years among a population-based sample of 6722 men and women (39% white, 27% black, 22% Hispanic, and 12% Chinese).[17]
  - —Chart 18-3 shows the HRs associated with CAC scores of 1 to 100, 101 to 300, and >300 compared with those without CAC (score=0), after adjustment for standard risk factors. People with CAC scores of 1 to 100 had ≈4 times greater risk and those with CAC scores >100 were 7 to 10 times more likely to experience a coronary event than those without CAC.
  - —CAC provided similar predictive value for coronary events in whites, Chinese, blacks, and Hispanics (HRs ranging from 1.15–1.39 for each doubling of coronary calcium).
  - —In MESA, CAC was noted to be highly predictive of CHD event risk across all age groups in a follow-up that extended to 8.5 years, which suggests that once CAC is known, chronological age has less importance. Compared with a CAC score of 0, CAC >100 imparted an increased multivariable-adjusted CHD event risk in the younger individuals (45–54 years old) with an HR of 12.4 (95% CI, 5.1–30.0). The respective risk was similar even in the very elderly (75–84 years of age) with an HR of 12.1 (95% CI, 2.9–50.2).[18]
- In another report of a community-based sample, not referred for clinical reasons, the South Bay Heart Watch examined CAC in 1461 adults (average age 66 years) with coronary risk factors, with a median of 7.0 years of follow-up.[19]
  - —Chart 18-4 shows the HRs associated with increasing CAC scores (relative to CAC=0 and <10% risk category) in low-risk (<10%), intermediate-risk (10%–15% and 16%–20%), and high-risk (>20%) FRS categories of estimated risk for CHD in 10 years. Increasing CAC scores further predicted risk in intermediate- and high-risk groups.
- In a study of healthy adults 60 to 72 years of age who were free of clinical CAD, predictors of the progression of CAC were assessed. Predictors tested included age, sex, race/ethnicity, smoking status, BMI, family history of CAD, CRP, several measures of DM, insulin levels, BP, and lipids. Insulin resistance, in addition to the traditional cardiac risk factors, independently predicts progression of CAC.[20] Clinically, however, it is not yet recommended to conduct serial scanning of CAC to measure effects of therapeutic interventions.
- A recent publication from MESA also used CAC, in particular, and carotid IMT to stratify CHD and CVD event risk in people with metabolic syndrome and DM; those with low levels of CAC or carotid IMT have CHD and CVD event rates as low as many people without metabolic syndrome and DM. Those with DM who have CAC scores <100 have annual CHD event rates of <1%.[21]
- It is noteworthy, as recently demonstrated in MESA in 5878 participants with a median of 5.8 years of follow-up, that the addition of CAC to standard risk factors resulted in significant improvement of classification of risk for incident CHD events, placing 77% of people in the highest or lowest risk categories compared with 69% based on risk factors alone. An additional 23% of those who experienced events were reclassified as high risk, and 13% with events were reclassified as low risk.[22] The contribution of CAC to risk prediction has also been observed in other cohorts, including both the Heinz Nixdorf Recall Study[23] and the Rotterdam Study.[24]
- An absence of CAC, observed in 40% to 50% of individuals, confers a very low risk for future cardiovascular events. In a meta-analysis of 13 studies assessing the relationship of CAC with adverse cardiovascular outcomes that included 71 595 asymptomatic patients, 29 312 patients (41%) did not have any evidence of CAC.[25] In a follow-up that averaged 3 to 5 years, 154 of 29 312 patients without CAC (0.47%) experienced a cardiovascular event compared with 1749 of 42 283 patients with CAC (4.14%). The cumulative RR was 0.15 (95% CI, 0.11–0.21; P<0.001). These findings were confirmed in MESA, which reported a rate of 0.52% for CHD events during a median of 4 years of follow-up among people with no detectable CAC.[26]
- The value of CAC zero has been confirmed in various high-risk groups. For example, in MESA, 38% of individuals with DM had CAC=0, and the annualized CHD and CVD event rates were 0.4% and 0.8%, respectively.[21] A recent publication[15] from MESA demonstrated a low hard CHD event rate per 1000 years during a median follow-up of 7.1 years across the entire spectrum of baseline FRS (0%–6%: 0.9; 6%–10%: 1.1; 10%–20%: 1.9; >20%: 2.5). Among high-risk individuals considered for various polypill criteria in MESA,[27] based on age and risk factors, the prevalence of CAC=0 ranged from 39% to 59%, and the respective rate of CHD events varied from 1.2 to 1.9 events per 1000 person-years during a median follow-up of 7.6 years.
- A recent meta-analysis[28] also highlighted the utility of CAC testing in the diabetic population. In this meta-analysis, 8 studies were included (n=6521; 802 events; mean follow-up 5.18 years). The RR for all-cause mortality or cardiovascular events or both comparing a total CAC score ≥10 with a score <10 was 5.47 (95% CI, 2.59–11.53; I^2=82.4%, P<0.001). For people with a CAC score <10, the posttest probability of the composite outcome was ≈1.8%, which represents a 6.8-fold reduction from the pretest probability, which suggests that those with low or absent CAC may facilitate risk stratification by enabling the identification of people at low risk within this high-risk population.[28]
- In the Heinz Nixdorf Recall Study,[29] CAC independently predicted stroke during a mean follow-up of 7.9 years. Cox proportional hazards regressions were used to examine CAC as a predictor of stroke in addition to established vascular risk factors (age, sex, SBP, LDL-C, HDL-C, DM, smoking, and AF). Study participants who had a stroke had significantly higher CAC values at baseline than the remaining subjects (median 104.8 [quartile 1, 14.0; quartile 3, 482.2] versus 11.2 [quartile 1, 0; quartile 3, 106.2]; P<0.001). In a

multivariable Cox regression, log10(CAC+1) was an independent stroke predictor (HR, 1.52; 95% CI, 1.19–1.92; *P*=0.001). CAC discriminated stroke risk specifically in participants in the low (<10%) and intermediate (10%–20%) FRS categories.[29]

- Recent studies have also suggested CAC also predicts cardiac events beyond stroke and MI.
- In the Rotterdam Study, CAC independently predicted incident HF during a median follow-up of 6.8 years. Those with severe CAC (>400) after adjustment for risk factors had a 4.1-fold higher risk (95% CI, 1.7–10.1) of HF than those with CAC scores of 0 to 10.[30] In addition, CAC substantially improved the risk classification of subjects (net reclassification index, 34.0%).
- In MESA, during a median follow-up period of 8.5 years, after accounting for risk factors, higher CAC scores were associated with increased risk for AF (CAC=0: HR, 1.0 [referent]; CAC=1–100: HR, 1.4 [95% CI, 1.01–2.0]; CAC=101–300: HR, 1.6 [95% CI, 1.1–2.4]; CAC >300: HR, 2.1 [95% CI, 1.4–2.9]). The addition of CAC to the FHS AF risk score yielded relative integrated discrimination improvement of 0.10 (95% CI, 0.061–0.15).[31]

CAC Progression and Risk

- A recent report in 4609 individuals who had baseline and repeat cardiac CT found that progression of CAC provided incremental information over baseline score, demographics, and cardiovascular risk factors in predicting future all-cause mortality.[32]
- More recently, data from 6778 people in MESA showed annual CAC progression was an average of 25 Agatston units, and among those without CAC at baseline, a 5-U annual change in CAC was associated with HRs of 1.4 and 1.5 for total and hard CHD events, respectively. Among those with CAC >0 at baseline, HRs per 100-U annual change in CAC were 1.2 and 1.3, respectively, and for those with annual progression ≥300 versus no progression, HRs were 3.8 and 6.3, respectively.[33] Progression of CAC in MESA was also shown to be greater in those with metabolic syndrome and DM than in those with neither condition, and progression of CAC in each of these conditions was associated with a greater future risk of CHD events.[34]
- In MESA, greater adherence to a healthy lifestyle based on a healthy lifestyle score was associated with slower progression of CAC and lower mortality rates relative to those with the most unhealthy lifestyle.[35]

Carotid IMT

Background

- Carotid IMT measures the thickness of 2 layers (the intima and media) of the wall of the carotid arteries, the largest conduits of blood going to the brain. Carotid IMT is thought to be an even earlier manifestation of atherosclerosis than CAC, because thickening precedes the development of frank atherosclerotic plaque. Carotid IMT methods are still being refined, so it is important to know which part of the artery was measured (common carotid, internal carotid, or bulb) and whether near and far walls were both measured. This information can affect the average-thickness measurement that is usually reported.
- Unlike CAC, everyone has some thickness to the layers of their arteries, but people who develop atherosclerosis have greater thickness. Ultrasound of the carotid arteries can also detect plaques and determine the degree of narrowing of the artery they may cause. Epidemiological data, including the data discussed below, have indicated that high-risk levels of thickening might be considered as those in the highest quartile or quintile for one's age and sex, or ≥1 mm.
- Although ultrasound is commonly used to diagnose plaque in the carotid arteries in people who have had strokes or who have bruits (sounds of turbulence in the artery), guidelines are limited as to screening of asymptomatic people with carotid IMT to quantify atherosclerosis or predict risk. However, some organizations have recognized that carotid IMT measurement by B-mode ultrasonography may provide an independent assessment of coronary risk.[36]

Prevalence and Association With Incident Cardiovascular Events

(See Charts 18-5 and 18-6.)

- The Bogalusa Heart Study measured carotid IMT in 518 black and white men and women at a mean age of 32±3 years. These men and women were healthy but overweight.[37]
  - —The mean values of carotid IMT for the different segments are shown in Chart 18-5 by sex and race. Men had significantly higher carotid IMT in all segments than women, and blacks had higher common carotid and carotid bulb IMTs than whites.
  - —Even at this young age, after adjustment for age, race, and sex, carotid IMT was associated significantly and positively with waist circumference, SBP, DBP, and LDL-C. Carotid IMT was inversely correlated with HDL-C levels. Participants with greater numbers of adverse risk factors (0, 1, 2, 3, or more) had stepwise increases in mean carotid IMT levels.
- In a subsequent analysis, the Bogalusa investigators examined the association of risk factors measured since childhood with carotid IMT measured in these young adults.[38] Higher BMI and LDL-C levels measured at 4 to 7 years of age were associated with increased risk for being >75th percentile for carotid IMT in young adulthood. Higher SBP and LDL-C and lower HDL-C in young adulthood were also associated with having high carotid IMT. These data highlight the importance of adverse risk factor levels in early childhood and young adulthood in the early development of atherosclerosis.
- Among both women and men in MESA, blacks had the highest common carotid IMT, but they were similar to whites and Hispanics in internal carotid IMT. Chinese participants had the lowest carotid IMT, in particular in the internal carotid, of the 4 ethnic groups (Chart 18-6).
- The NHLBI's CHS reported follow-up of 4476 men and women ≥65 years of age (mean age 72 years) who were free of CVD at baseline.[39]
  - —Mean maximal common carotid IMT was 1.03±0.20 mm, and mean internal carotid IMT was 1.37±0.55 mm.

—After a mean follow-up of 6.2 years, those with maximal combined carotid IMT in the highest quintile had a 4- to 5-fold greater risk for incident heart attack or stroke than those in the bottom quintile. After adjustment for other risk factors, there was still a 2- to 3-fold greater risk for the top versus the bottom quintile.

- In MESA, during a median follow-up of 3.3 years, IMT rate of change of 0.5 mm/year was associated with an HR of 1.23 (95% CI, 1.02–1.48) for incident stroke. The upper quartile of IMT rate of change had an HR of 2.18 (95% CI, 1.07–4.46) compared with the lower 3 quartiles combined.[40]
- A study of 441 individuals ≤65 years of age without a history of CAD, DM, or hyperlipidemia who were examined for carotid IMT found 42% had high-risk carotid ultrasound findings (carotid IMT ≥75th percentile, adjusted for age, sex, and race or presence of plaque). Among those with an FRS ≤5%, 38% had high-risk carotid ultrasound findings.[41]
- Conflicting data have been reported on the contribution of carotid IMT to risk prediction. In 13 145 participants in the NHLBI's ARIC study, the addition of carotid IMT combined with identification of plaque presence or absence to traditional risk factors reclassified risk in 23% of individuals overall, with a net reclassification improvement of 9.9%. There was a modest but statistically significant improvement in the area under the receiver operating characteristic curve, from 0.742 to 0.755.[42] In contrast, data reported recently from the Carotid Atherosclerosis Progression Study observed a net reclassification improvement of −1.4% that was not statistically significant.[43]
- In the Rotterdam Study, 3580 nondiabetic individuals aged 55 to 75 years were followed up for a median of 12.2 years. In older men, addition of carotid IMT to Framingham risk factors did not improve prediction of hard CHD or stroke. In older women, addition of carotid IMT to Framingham risk factors yielded a net reclassification improvement in women of 8.2% (P=0.03) for hard CHD and 8.0% (P=0.06) for stroke.[44]
- A recent study from a consortium of 14 population-based cohorts consisting of 45 828 individuals followed up for a median of 11 years demonstrated little additive value of common carotid IMT to FRS for purposes of discrimination and reclassification as far as incident MI and stroke were concerned. The C statistics of the model with FRS alone (0.757; 95% CI, 0.749–0.764) and with addition of common carotid IMT (0.759; 95% CI, 0.752–0.766) were similar. The net reclassification improvement with the addition of common carotid IMT was small (0.8%; 95% CI, 0.1%–1.6%). In those at intermediate risk, the net reclassification improvement was 3.6% among all individuals (95% CI, 2.7%–4.6%).[45]
- Furthermore, a recent study from the same consortium of a population-based cohort reported no added value of measurement of mean common carotid IMT in individuals with HBP for improving cardiovascular risk prediction. For those at intermediate risk, the addition of mean common carotid IMT to an existing cardiovascular risk score resulted in small but statistically significant improvement in risk prediction.[46]
- In a recent study, however, carotid plaque burden measured via 3-dimensional carotid ultrasound showed promise in improving CVD risk prediction. The prospective BioImage Study enrolled 5808 asymptomatic US adults (mean age 69 years, 56.5% female). Carotid plaque areas from both carotid arteries were summed as the carotid plaque burden. The primary end point was the composite of major adverse cardiac events (cardiovascular death, MI, and ischemic stroke). In a 2.7-year median follow-up, major adverse cardiac events occurred in 216 patients (4.2%), of which 82 (1.5%) were primary events. After adjustment for risk factors, the HRs for major adverse cardiac events were 1.45 (95% CI, 0.67–3.14) and 2.36 (95% CI, 1.13–4.92) with increasing carotid plaque burden tertile. Net reclassification improved significantly with carotid plaque burden (0.23).[47]

CAC and Carotid IMT

- In the NHLBI's MESA, a study of white, black, Chinese, and Hispanic adults 45 to 84 years of age, carotid IMT and CAC were found to be commonly associated, but patterns of association differed somewhat by sex and race.[48]
  - —Common and internal carotid IMT were greater in women and men who had CAC than in those who did not, regardless of ethnicity.
  - —Overall, CAC prevalence and scores were associated with carotid IMT, but associations were somewhat weaker in blacks than in other ethnic groups.
  - —In general, blacks had the thickest carotid IMT of all 4 ethnic groups, regardless of the presence of CAC.
  - —Common carotid IMT differed little by race/ethnicity in women with any CAC, but among women with no CAC, IMT was higher among blacks (0.86 mm) than in the other 3 groups (0.76–0.80 mm).
- In a more recent analysis from MESA, the investigators reported on follow-up of 6779 men and women in 4 ethnic groups over 9.5 years and compared the predictive utility of carotid IMT, carotid plaque, and CAC (presence and burden).[49]
  - —CAC presence was a stronger predictor of incident CVD and CHD than carotid ultrasound measures.
  - —Mean IMT ≥75th percentile (for age, sex, and race) alone did not predict events. Compared with traditional risk factors, C statistics for CVD (C=0.756) and CHD (C=0.752) increased the most by the addition of CAC presence (CVD, 0.776; CHD, 0.784; P<0.001) followed by carotid plaque presence (CVD, C=0.760; CHD, C=0.757; P<0.05).
  - —Compared with risk factors (C=0.782), carotid plaque presence (C=0.787; P=0.045) but not CAC (C=0.785; P=0.438) improved prediction of stroke/TIA.
- Investigators from the NHLBI's CARDIA and MESA studies examined the burden and progression of subclinical atherosclerosis among adults <50 years of age. Ten-year and lifetime risks for CVD were estimated for each participant, and the participants were stratified into 3 groups: (1) those with low 10-year (<10%) and low lifetime (<39%) predicted risk for CVD; (2) those with low 10-year (<10%) but high lifetime (≥39%) predicted risk; and (3) those with high 10-year risk (>10%). The latter group had the highest burden and greatest progression of subclinical atherosclerosis. Given the young age of those studied, ≈90% of participants were at low 10-year risk, but of these, half had high predicted lifetime risk. Compared with those with

low short-term/low lifetime predicted risks, those with low short-term/high lifetime predicted risk had significantly greater burden and progression of CAC and significantly greater burden of carotid IMT, even at these younger ages. These data confirm the importance of early exposure to risk factors for the onset and progression of subclinical atherosclerosis.[50]

CT Angiography

- CT angiography is widely used by cardiologists to aid in the diagnosis of CAD, particularly when other test results may be equivocal. It is also of interest because of its ability to detect and possibly quantitate overall plaque burden and certain characteristics of plaques that may make them prone to rupture, such as positive remodeling or low attenuation.
- Compared with the established value of CAC scanning for risk reclassification in asymptomatic patients, there are limited data regarding the utility of CT angiography in asymptomatic people. This was recently assessed by the investigators of the CONFIRM registry,[51] from which >7500 asymptomatic subjects with CAC and CT angiography were followed up for death and nonfatal MI for a median of 2 years. Overall, 2.2% either died or experienced nonfatal MI, and in multivariable models, compared with those without atherosclerosis, there was increasing risk across groups with increasing degrees of atherosclerosis measured by CT angiography. However, after the inclusion of CAC in the multivariable risk model, CT angiography did not provide incremental prognostic value over this short period of follow-up.[51] In another study from the CONFIRM registry, it was noted that coronary CT angiography provided incremental prognostic utility for prediction of mortality and nonfatal MI for asymptomatic individuals with moderately high CAC scores but not for lower or higher CAC scores. The value of coronary CT angiography over the FRS was demonstrated in individuals with a CAC score >100 (increment in C statistic, 0.24; net reclassification index, 0.62; all $P<0.001$) but not among those with CAC scores ≤100 (all $P>0.05$).[52]
- Because of the limited outcome data in asymptomatic people, as well as the associated expense and risk of CT angiography (including generally higher radiation levels than CT scanning to detect CAC), current guidelines do not recommend its use as a screening tool for assessment of cardiovascular risk in asymptomatic people.[2]

Measures of Vascular Function and Incident CVD Events

Background

- Measures of arterial tonometry (stiffness) are based on the concept that pulse pressure has been shown to be an important risk factor for CVD. Arterial tonometry offers the ability to directly and noninvasively measure central pulse wave velocity in the thoracic and abdominal aorta.
- Brachial FMD is a marker for nitric oxide release from the endothelium that can be measured by ultrasound. Impaired FMD is an early marker of CVD.
- Recommendations have not been specific, however, as to which, if any, measures of vascular function may be useful for CVD risk stratification in selected patient subgroups. Because of the absence of significant prospective data relating these measures to outcomes, latest guidelines do not currently recommend measuring either FMD or arterial stiffness for cardiovascular risk assessment in asymptomatic adults.[2]

Arterial Tonometry and CVD

- The Rotterdam Study measured arterial stiffness in 2835 elderly participants (mean age 71 years).[53] They found that as aortic pulse wave velocity increased, the risk of CHD was 1.72 (second versus first tertile) and 2.45 (third versus first tertile). Results remained robust even after accounting for carotid IMT, ABI, and pulse pressure.
- A study from Denmark of 1678 individuals aged 40 to 70 years found that each 1-SD increment in aortic pulse wave velocity (3.4 m/s) increased CVD risk by 16% to 20%.[54]
- The FHS measured several indices of arterial stiffness, including pulse wave velocity, wave reflection, and central pulse pressure.[55] They found that not only was higher pulse wave velocity associated with a 48% increased risk of incident CVD events, but pulse wave velocity additionally improved CVD risk prediction (integrated discrimination improvement of 0.7%, $P<0.05$).

FMD and CVD

- MESA measured FMD in 3026 participants (mean age 61 years) who were free of CVD. As FMD increased (ie, improved brachial function), the risk of CVD was 16% lower.[56] FMD also improved CVD risk prediction compared with the FRS by improving net reclassification by 29%.
- A recent meta-analysis assessed relation of FMD with CVD events. Thirteen studies involving 11 516 individuals without established CVD, with a mean duration of 2 to 7.2 years and adjusted for age, sex, and risk factors, reported a multivariate RR of 0.93 (95% CI, 0.90–0.96) per 1% increase in brachial FMD.[57]

Comparison of Measures

- In MESA, a comparison of 6 risk markers—CAC, ABI, high-sensitivity CRP, carotid IMT, brachial FMD, and family history of CHD—and their clinical utility over FRS was evaluated in 1330 intermediate-risk individuals. After 7.6 years of follow-up, CAC, ABI, high-sensitivity CRP, and family history were independently associated with incident CHD in multivariable analyses (HRs of 2.6, 0.79, 1.28, and 2.18, respectively), but carotid IMT and brachial FMD were not. CAC provided the highest incremental improvement over the FRS (0.784 for both CAC and FRS versus 0.623 for FRS alone), as well as the greatest net reclassification improvement (0.659).[58]
- Similar findings were also noted in the Rotterdam Study, in which among 12 CHD risk markers, improvements in FRS predictions were most statistically and clinically significant with the addition of CAC scores.[59]

Utility for Risk Stratification for Treatment

- CAC has been examined in multiple studies for its potential to identify those most likely and not likely to benefit from treatment.
- In a study of 950 participants from MESA who met JUPITER clinical trial entry criteria (risk factors plus LDL-C <130 mg/dL and CRP ≥2 mg/L) were identified and stratified according to CAC scores of 0, 1 to 100, or >100; CHD event rates were calculated, and the number needed to treat was calculated by applying the benefit found in JUPITER to the event rates found in each of these groups. For CHD, the predicted NNT_5 was 549 for those with CAC of 0, 94 for scores of 1 to 100, and 24 for scores >100.[60]
- In a similar fashion, 2 studies extrapolated the NNT_5 for LDL-C lowering by statins, applying the 30% RR reduction associated with a 1 mmol/L (39 mg/dL) reduction in LDL-C from a Cochrane meta-analysis of statin therapy in primary prevention across the spectrum of lipid abnormalities (LDL-C ≥130 mg/dL, HDL-C <40 mg/dL for men or <50 mg/dL for women, and triglycerides ≥150 mg/dL), as well as across 10-year FRS categories (0–6%, 6–10%, 10–20%, and >20%). The estimated NNT_5 for preventing 1 CVD event across dyslipidemia categories in this MESA cohort ranged from 23 to 30 in those with CAC ≥100.[14] The NNT_5 was 30 in participants with no lipid abnormality and CAC >100, whereas the NNT_5 was 154 in those with 3 lipid abnormalities and CAC=0.[14] A very high NNT_5 of 186 and 222, respectively, was estimated to prevent 1 CHD event in the absence of CAC among those with 10-year FRS of 11% to 20% and >20%. The respective estimated NNT_5 were as low as 36 and 50 with the presence of a very high CAC score (>300) among those with 10-year FRS of 0% to 6% and 6% to 10%, respectively.[27] These collective data show the utility of CAC in identifying those most likely to benefit from statin treatment across the spectrum of risk profiles with an appropriate number needed to treat.
- Similarly, CAC testing also identified appropriate candidates who may derive the highest benefit with aspirin therapy. In MESA, individuals with CAC ≥100 had an estimated net benefit with aspirin regardless of their traditional risk status; the estimated NNT_5 was 173 for individuals classified as having <10% FRS and 92 for individuals with ≥10% FRS, and the estimated 5-year number needed to harm was 442 for a major bleed.[61] Conversely, individuals with zero CAC had unfavorable estimates (estimated NNT_5 of 2036 for individuals with <10% FRS and 808 for individuals with ≥10% FRS; estimated 5-year number needed to harm of 442 for a major bleed). Sex-specific and age-stratified analyses showed similar results.
- A recent study from MESA also examined the role of CAC testing to define the target population to treat with a polypill.[27] The 5-year NNT_5 to prevent 1 event was estimated by applying the expected 62% CHD event reduction associated with the use of the polypill (based on TIPS). The estimated NNT_5 to prevent 1 CHD event ranged from 170 to 269 for patients with CAC=0, from 58 to 79 for those with CAC scores from 1 to 100, and from 25 to 27 for those with CAC scores >100,[27] which enabled significant reductions in the population considered for treatment with more selective use of the polypill and, as a result, avoidance of treatment of those who were unlikely to benefit.

Table 18-1. CAC Scores for the 75th Percentile of Men and Women of Different Race/Ethnic Groups, at Specified Ages

	75th Percentile CAC Scores*			
Age, y	Black	Chinese	Hispanic	White
Women				
45	0	0	0	0
55	0	2	0	1
65	26	45	19	54
75	138	103	116	237
Men				
45	0	3	0	0
55	15	34	27	68
65	95	121	141	307
75	331	229	358	820

CAC indicates coronary artery calcification.

*The 75th percentile CAC score is the score at which 75% of people of the same age, sex, and race have a score at or below this level and 25% of people of the same age, sex, and race have a higher score.

Source: MESA (Multi-Ethnic Study of Atherosclerosis) CAC Tools Web site.[62]

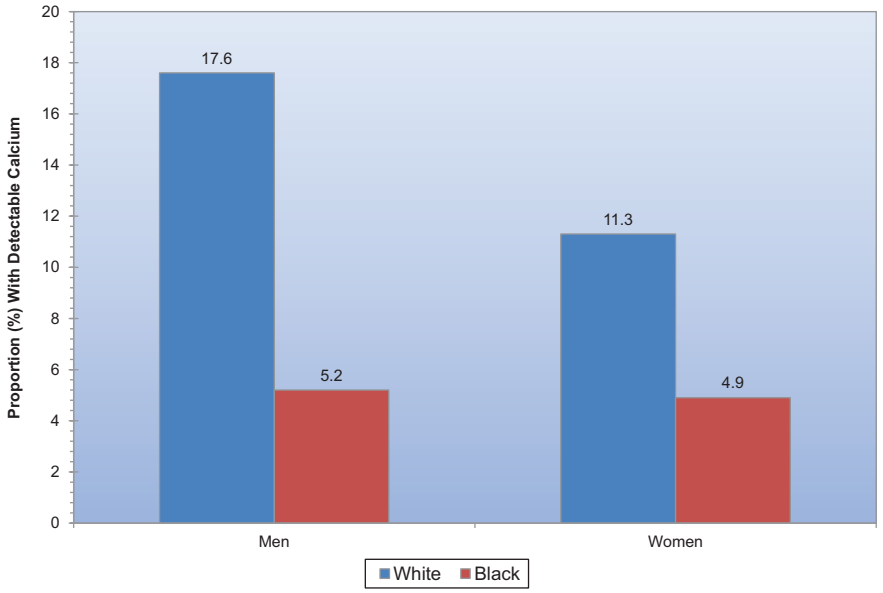

Chart 18-1. Prevalence (%) of coronary calcium: US adults 33 to 45 years of age. *P*<0.0001 across race-sex groups. Data derived from Loria et al.[9]

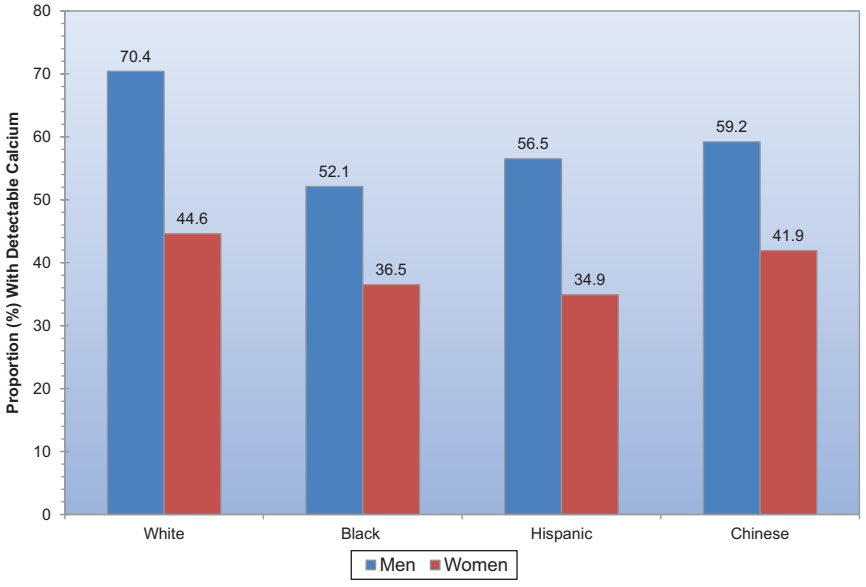

Chart 18-2. Prevalence (%) of coronary calcium: US adults 45 to 84 years of age. *P*<0.0001 across ethnic groups in both men and women. Data derived from Bild et al.[11]

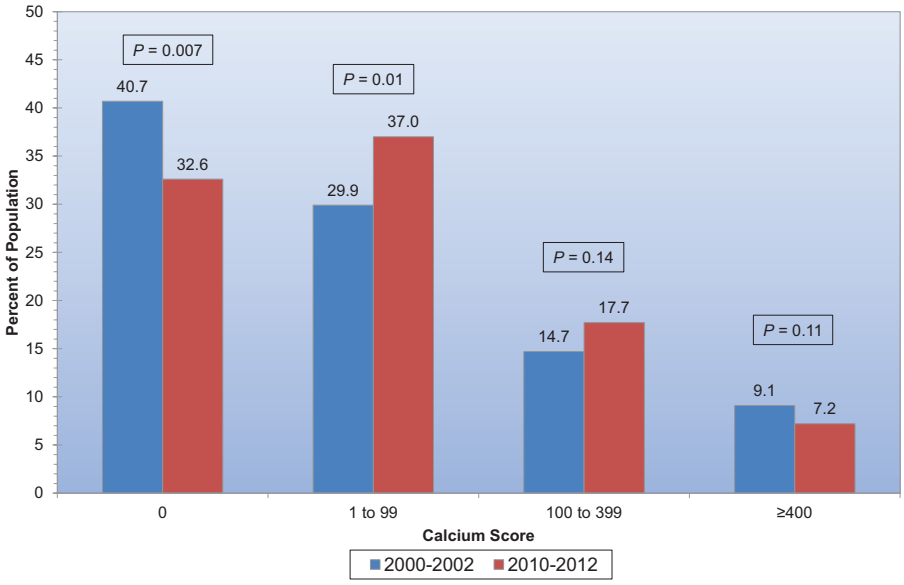

Chart 18-3. Ten-year trends in CAC in individuals without clinical cardiovascular disease in MESA. Data derived from Bild et al.[16]

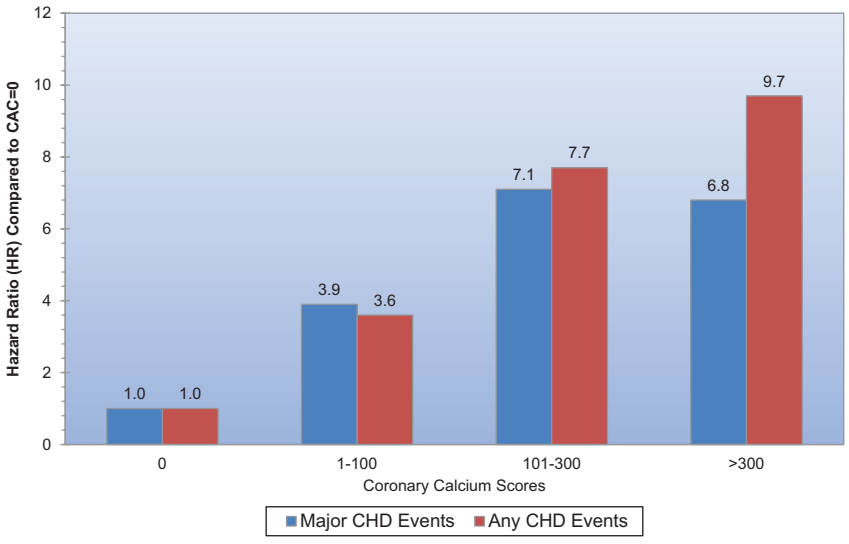

Chart 18-4. Hazard ratios (HRs) for coronary heart disease (CHD) events associated with coronary calcium scores: US adults 45 to 84 years of age (reference group, coronary artery calcification [CAC]=0). All HRs $P<0.0001$. Major CHD events included myocardial infarction and death attributable to CHD; any CHD events included major CHD events plus definite angina or definite or probable angina followed by revascularization. Data derived from Detrano et al.[17]

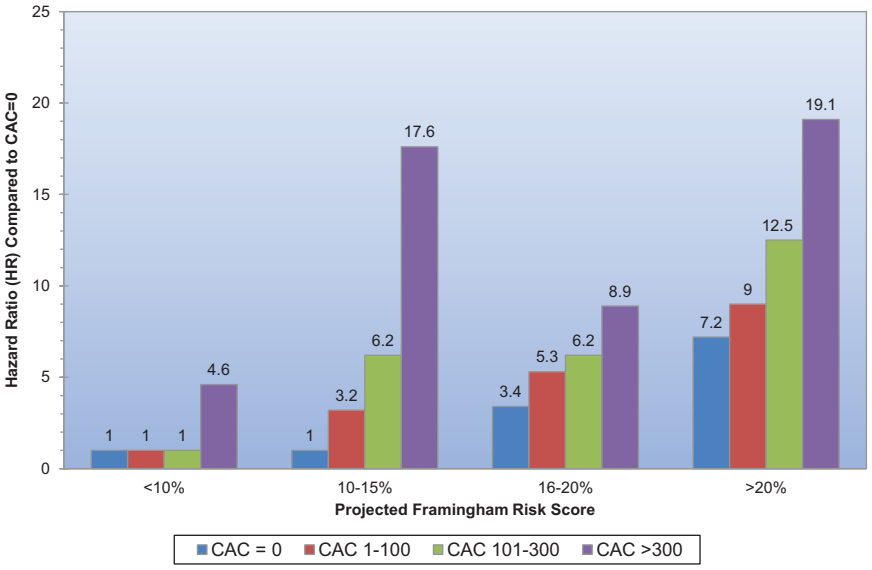

Chart 18-5. Hazard ratios (HRs) for coronary heart disease events associated with coronary calcium scores: US adults (reference group, coronary artery calcification [CAC]=0 and Framingham Risk Score <10%). Coronary heart disease events included nonfatal myocardial infarction and death attributable to coronary heart disease. Data derived from Greenland et al.[19]

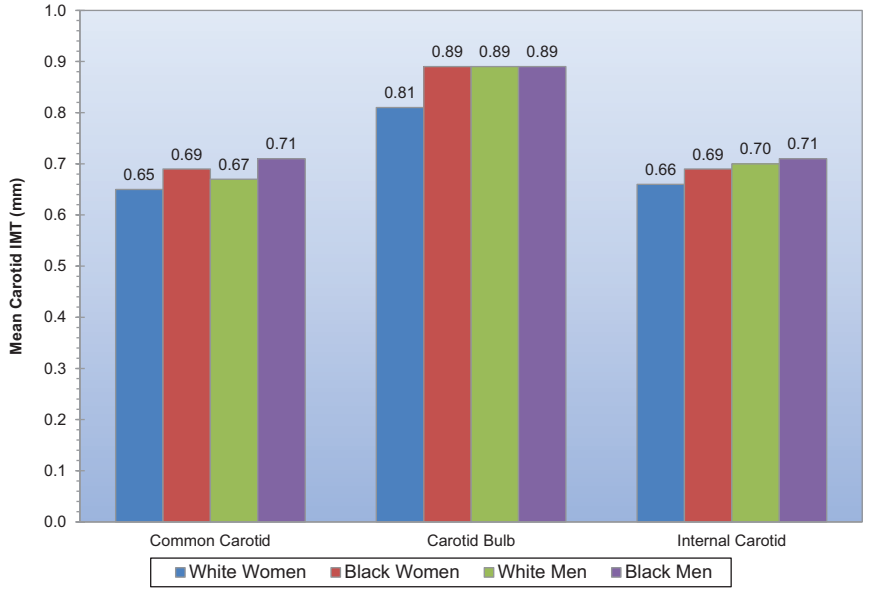

Chart 18-6. Mean values of carotid intima-media thickness (IMT) for different carotid artery segments in younger adults by race and sex (Bogalusa Heart Study). Data derived from Urbina et al.[37]

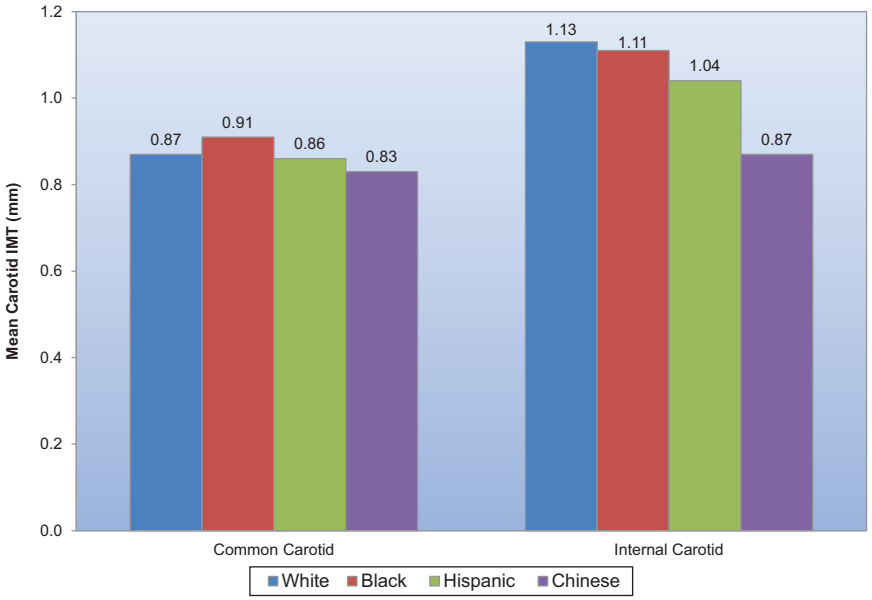

Chart 18-7. Mean values of carotid intima-media thickness (IMT) for different carotid artery segments in older adults, by race. Data derived from Manolio et al.[48]

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19. Coronary Heart Disease, Acute Coronary Syndrome, and Angina Pectoris

See Tables 19-1 and 19-2 and Charts 19-1 through 19-11; see Glossary (Chapter 27) for details and definitions.

Coronary Heart Disease

ICD-9 410 to 414, 429.2; ICD-10 I20 to I25 (includes MI ICD-10 I21 to I22).

Prevalence

(See Table 19-1 and Charts 19-1 and 19-2.)

- On the basis of data from NHANES 2009 to 2012 (NHLBI tabulation), an estimated 15.5 million Americans ≥20 years of age have CHD (Chart 19-1).
  - —Total CHD prevalence is 6.2% in US adults ≥20 years of age. CHD prevalence is 7.6% for men and 5.0% for women.
  - —Among non-Hispanic whites, CHD prevalence is 7.8% for men and 4.6% for women.
  - —Among non-Hispanic blacks, CHD prevalence is 7.2% for men and 7.0% for women.
  - —Among Hispanics, CHD prevalence is 6.7% for men and 5.9% for women.
- On the basis of data from the 2014 NHIS[1]:
  - —Among Asians ≥18 years of age, the estimate is 3.3%.
  - —Among American Indian/Alaska Natives ≥18 years of age, the estimate is 6.0%; however, this is not reliable.
- According to data from NHANES 2009 to 2012 (NHLBI tabulation), the overall prevalence for MI is 2.8% in US adults ≥20 years of age. MI prevalence is 4.0% for men and 1.8% for women (Chart 19-2).
  - —Among non-Hispanic whites, MI prevalence is 4.1% for men and 1.8% for women.
  - —Among non-Hispanic blacks, MI prevalence is 3.4% for men and 2.2% for women.
  - —Among Hispanics, MI prevalence is 3.5% for men and 1.7% for women.
- Data from the BRFSS 2013 survey indicated that 4.0% of respondents had been told that they had had an MI. The highest prevalence was in West Virginia (6.5%), and the

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Abbreviations Used in Chapter 19

ACC	American College of Cardiology
ACS	acute coronary syndrome
ACTION	Acute Coronary Treatment and Intervention Outcomes Network
AHA	American Heart Association
AMI	acute myocardial infarction
AP	angina pectoris
ARIC	Atherosclerosis Risk in Communities study
BMI	body mass index
BP	blood pressure
BRFSS	Behavioral Risk Factor Surveillance System
CABG	coronary artery bypass graft
CAD	coronary artery disease
CARDIA	Coronary Artery Risk Development in Young Adults
CHD	coronary heart disease
CHS	Cardiovascular Health Study
CI	confidence interval
CRUSADE	Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines
CVD	cardiovascular disease
D2B	door-to-balloon
DM	diabetes mellitus
ECG	electrocardiogram
ED	emergency department
EHS-ACS-II	second Euro Heart Survey on ACS
EMS	emergency medical services
FHS	Framingham Heart Study
GRACE	Global Registry of Acute Coronary Events
GWTG	Get With The Guidelines
HCUP	Healthcare Cost and Utilization Project
HD	heart disease
HDL-C	high-density lipoprotein cholesterol
HF	heart failure
ICD-9	*International Classification of Diseases, 9th Revision*
ICD-10	*International Classification of Diseases, 10th Revision*
JHS	Jackson Heart Study
MEPS	Medical Expenditure Panel Survey
MESA	Multi-Ethnic Study of Atherosclerosis
MI	myocardial infarction
NAMCS	National Ambulatory Medical Care Survey
NCDR	National Cardiovascular Data Registry
NCHS	National Center for Health Statistics
NH	non-Hispanic
NHAMCS	National Hospital Ambulatory Medical Care Survey
NHANES	National Health and Nutrition Examination Survey
NHDS	National Hospital Discharge Survey
NHIS	National Health Interview Study
NHLBI	National Heart, Lung, and Blood Institute
NRMI	National Registry of Myocardial Infarction
NSTEMI	non–ST-segment–elevation myocardial infarction
OHCA	out-of-hospital cardiac arrest
OR	odds ratio
PCI	percutaneous coronary intervention
SBP	systolic blood pressure
STEMI	ST-segment–elevation myocardial infarction
TC	total cholesterol
UA	unstable angina
WISE	Women's Ischemia Syndrome Evaluation
YLL	years of life lost

lowest was in Minnesota (2.7%). In the same survey, 3.8% of respondents had been told that they had angina or CHD. The highest prevalence was in West Virginia (6.2%), and the lowest was in Hawaii (2.3%).[2]

- Projections show that by 2030, prevalence of CHD will increase ≈18% from 2013 estimates (AHA computation, based on methodology described in Heidenreich et al[3]).

Incidence

(See Table 19-1 and Charts 19-3 through 19-5.)

- Approximately every 42 seconds, an American will have an MI (AHA computation).
- On the basis of data from the ARIC study[4] of the NHLBI:
  - —This year, ≈660 000 Americans will have a new coronary event (defined as first hospitalized MI or CHD death), and ≈305 000 will have a recurrent event. It is estimated that an additional 160 000 silent MIs occur each year. That assumes that ≈21% of the 750 000 first and recurrent MIs are silent.
  - —The estimated annual incidence of MI is 550 000 new attacks and 200 000 recurrent attacks.
  - —Average age at first MI is 65.1 years for men and 72.0 years for women.
- On the basis of the NHLBI-sponsored FHS[5]:
  - —CHD makes up more than half of all cardiovascular events in men and women <75 years of age.
  - —The incidence of CHD in women lags behind men by 10 years for total CHD and by 20 years for more serious clinical events such as MI and sudden death.
- In the NHLBI-sponsored ARIC study, among participants 35 to 84 years of age, the average age-adjusted first MI or fatal CHD rates per 1000 population were as follows: white men, 3.7; black men, 6.2; white women, 2.1; and black women, 4.1 (unpublished data from ARIC Surveillance 2005–2012, NHLBI).
- Incidence rates for MI in the NHLBI-sponsored ARIC study are displayed in Charts 19-3 and 19-4, stratified by age, race, and sex. The annual age-adjusted rates per 1000 population of first MI (2005–2012) were 5.3 in black men, 3.3 in white men, 3.6 in black women, and 1.9 in white women (unpublished data from ARIC Surveillance 2005–2012, NHLBI).

Trends in Incidence

- A number of studies have examined temporal trends in the incidence of MI. Geographic differences in patient populations, temporal changes in the criteria used to diagnosis MI, and differences in study methodology increase the complexity of interpreting these studies; however, the overall body of literature suggests that the incidence of MI has declined significantly over time, including over the past decade.
- Analysis of >40 years of physician-validated AMI data in the NHLBI's FHS found that AMI rates diagnosed by electrocardiographic criteria declined ≈50%, with a concomitant 2-fold increase in rates of AMI diagnosed by blood markers.[6]
- In Olmsted County, MN, between 1995 and 2012, the population rate of MI declined 3.3% per year; however, these declines varied among types of MI, with the greatest declines occurring for prehospital fatal MI.[7]
- Data from Kaiser Permanente Northern California showed that the age- and sex-adjusted incidence rate of hospitalizations for MI changed from 274 per 100 000 person-years in 1999 to 208 per 100 000 person-years in 2008. Furthermore, the age- and sex-adjusted incidence rate of hospitalizations for STEMI changed from 133 per 100 000 person-years in 1999 to 50 per 100 000 person-years in 2008 (P linear trend <0.001). The trajectory of the age- and sex-adjusted incidence rate of hospitalizations for NSTEMI did not change significantly over the entire study period, although it did show a significant decline after troponin became widely used to diagnose MI.[8]
- From 1987 to 2011, the age- and biomarker-adjusted incidence rates of hospitalization for AMI or fatal CHD decreased by 5.0% per year (95% CI, −5.3% to −4.7%) among white men, 3.9% per year (95% CI, −4.4% to −3.5%) among white women, 2.2% per year (95% CI, −2.8% to −1.6%) among black men, and 3.4% per year (95% CI, −4.2% to −2.7%) among black women in the ARIC study (1987–2011).[9]
- From 1999 to 2011, the incidence of hospitalized MI decreased from 1283 to 901 per 100 000 person-years among Medicare fee-for-service beneficiaries. The observed declines were independent of age, race, or sex.[10]
- Declines in MI incidence among Medicare fee-for-service beneficiaries occurred in all US census divisions between 1999 and 2008 in this population, although wide geographic disparities were observed throughout the study period.[11]
- On the basis of data from the NHIS, the NHDS, and the National Vital Statistics System, rates of MI among people with DM declined by 67.8% between 1990 and 2010, falling from 141.1 events per 10 000 person-years in 1990 to 45.5 per 10 000 person-years in 2010. By comparison, rates of MI in nondiabetic individuals fell by 31.2%, from 37.5 per 10 000 to 25.8 per 10 000.[12]

Predicted Risk

- Mean predicted 10-year risk for CHD among adults aged 30 to 74 years decreased from 7.2% during 1999 to 2000 to 6.5% during 2009 to 2010 (P=0.005). Mean predicted risk declined among men, women, whites, and adults 40 to 59, 50 to 59, and 60 to 74 years of age. Risk increased nonsignificantly among African American adults.[13]
- Individuals with atherosclerotic stroke should be included among those deemed to be at high risk (20% over 10 years) of further atherosclerotic coronary events. For primary prevention, ischemic stroke should be included among CVD outcomes in absolute risk assessment algorithms. The inclusion of atherosclerotic ischemic stroke as a high-risk condition has important implications, because the number of people considered to be at high risk will increase over time.[14]
- A survey of US family physicians, general internists, and cardiologists found that 41% of respondents reported using global CHD risk assessment at least occasionally.[15]
- Lifetime risk for CHD varies drastically as a function of risk factor profile. With an optimal risk factor profile, lifetime risk for CHD is 3.6% for men and <1% for women; with ≥2 major risk factors, it is 37.5% for men and 18.3% for women.[16]

Mortality

- Based on 2013 mortality data[17]
  - —CHD was an underlying cause of death in ≈1 of every 7 deaths in the United States in 2013.
  - —CHD mortality was 370 213, and CHD any-mention mortality was 538 239.
  - —MI mortality was 116 793. MI any-mention mortality was 153 331 (NCHS, NHLBI tabulation).
  - —The overall CHD death rate per 100 000 was 102.6.
  - —From 2003 to 2013, the annual death rate attributable to CHD declined 38.0% and the actual number of deaths declined 22.9% (NHLBI computation).
  - —CHD death rates per 100 000 were 141.8 for non-Hispanic white males, 155.1 for non-Hispanic black males, and 104.7 for Hispanic males; for non-Hispanic white females, the rate was 75.0; for non-Hispanic black females, it was 94.7; and for Hispanic females, it was 61.3.
  - —76% of CHD deaths occurred out of the hospital. According to NCHS mortality data, 280 808 CHD deaths occur out of the hospital or in hospital EDs annually (NCHS, AHA tabulation).
  - —The estimated average number of YLL because of an MI death is 16.9 (NHLBI tabulation).
- Approximately 34% of the people who experience a coronary event in a given year will die of it, and ≈15% who experience a heart attack (MI) will die of it (AHA computation).
- A study of 1275 health maintenance organization enrollees 50 to 79 years of age who had cardiac arrest showed that the incidence of OHCA was 6.0/1000 subject-years in subjects with any clinically recognized HD compared with 0.8/1000 subject-years in subjects without HD. Among enrollees with HD, incidence was 13.6 and 21.9 per 1000 subject-years in those with prior MI and with HF, respectively.[18]
- Researchers investigating variation in hospital-specific 30-day risk-stratified mortality rates for patients with AMI found teaching status, number of hospital beds, AMI volume, cardiac facilities available, urban/rural location, geographic region, hospital ownership type, and socioeconomic status profile of the patients were all significantly associated with mortality rates. However, a substantial proportion of variation in outcomes for patients with AMI between hospitals remains unexplained by measures of hospital characteristics.[19]

Temporal Trends in Mortality

- The decline in CHD mortality rates in part reflects the shift in the pattern of clinical presentations of AMI. In the past decade, there has been a marked decline in STEMI (from 133 to 50 cases per 100 000 person-years).[8]
  - —In Olmsted County, MN, the age- and sex-adjusted 30-day case fatality rate decreased by 56% from 1987 to 2006.[20]
  - —In Worcester, MA, the hospital case fatality rates, 30-day post-admission case fatality rates, and 1-year postdischarge case fatality rates for STEMI were 11.1%, 13.2%, and 10.6%, respectively, in 1997 and 9.7%, 11.4%, and 8.4%, respectively, in 2005. The hospital case fatality rates, 30-day postadmission case fatality rates, and 1-year postdischarge case fatality rates for NSTEMI were 12.9%, 16.0%, and 23.1%, respectively, in 1997 and 9.5%, 14.0%, and 18.7%, respectively, in 2005.[21]
  - —Among enrollees of the Kaiser Permanente Northern California healthcare delivery system, the age- and sex-adjusted 30-day mortality rate for MI dropped from 10.5% in 1999 to 7.8% in 2008, and the 30-day mortality rate for NSTEMI dropped from 10.0% in 1999 to 7.6% in 2008.[8]
  - —Among Medicare fee-for-service beneficiaries, between 1999 and 2011, the 30-day mortality rate after hospitalized MI declined by 29.4%.[10] Declines in 30-day mortality after MI occurred in all US census divisions between 2000 and 2008.[11]
- CHD death rates have fallen from 1968 to the present. Analysis of NHANES (NCHS) data compared CHD death rates between 1980 and 2000 to determine how much of the decline in deaths attributable to CHD over that period could be explained by the use of medical and surgical treatments versus changes in CVD risk factors (resulting from lifestyle/behavior). It was estimated that ≈47% of the decrease in CHD deaths was attributable to treatments, including the following[22]:
  - —Primary prevention, including antihypertensive and lipid-lowering treatments (12%)
  - —Secondary preventive therapies after MI or revascularization (11%)
  - —Initial treatments for AMI or UA (10%)
  - —Treatments for HF (9%)
  - —Revascularization for chronic angina (5%)
- It was also estimated that a similar amount of the reduction in CHD deaths, ≈44%, was attributable to changes in risk factors, including the following[22]:
  - —Lower TC (24%)
  - —Lower SBP (20%)
  - —Lower smoking prevalence (12%)
  - —Decreased physical inactivity (5%)
  - —Nevertheless, these favorable improvements in risk factors were offset in part by increases in BMI and in DM prevalence, which accounted for an increased number of deaths (8% and 10%, respectively).

Risk Factors

Risk factors for CHD act synergistically to increase CHD risk, as shown in the examples in Charts 19-6 and 19-7.

Awareness of Warning Signs and Risk Factors for HD

- Women's awareness that CVD is their leading cause of death increased from 30% in 1997 to 56% in 2012.[23]
  - —Depending on age, 44% to 50% identified HD/heart attack as the leading cause of death for women, a significant increase from 16% to 34% in the original 1997 survey.
  - —The percentages of women identifying warning signs for a heart attack were as follows: pain in the chest, neck, shoulder, and arm—56%; shortness of breath—38%; chest tightness—17%; nausea—18%; and fatigue—10%.
  - —The 5 most commonly cited HD prevention strategies in 2012 were maintaining a healthy BP (78%), seeing the doctor (78%), and increasing fiber intake, eating food with antioxidants, and maintaining healthy cholesterol levels (each 66%).

—Among online survey participants, 21% responded that their doctor had talked to them about HD risk. Rates were lower among Hispanic women (12%) than whites (22%) or blacks (22%) and increased with age from 6% (25–34 years) to 33% (≥65 years).

Time of Symptom Onset and Arrival at Hospital

- A meta-analysis of 48 studies enrolling >1.8 million patients showed that off-hours presentation for MI was associated with higher short-term mortality. In addition, those patients with STEMI who presented off hours had longer door-to-balloon times.[24]
- System improvements in Dallas County, TX, resulted in decreases in the median time from symptom onset to balloon (catheterization) from the fourth quarter of 2010 to the first quarter of 2012.[25]
- Data from CRUSADE and the NCDR ACTION Registry–GWTG showed a longer median time to hospital presentation in men (3 hours) than in women (2.8 hours; $P<0.001$). From 2002 to 2007, presentation time did not change significantly in men or women.[26]
- Individuals with documented CHD have 5 to 7 times the risk of having a heart attack or dying as the general population. Survival rates improve after a heart attack if treatment begins within 1 hour; however, most patients are admitted to the hospital 2.5 to 3 hours after symptoms begin. More than 3500 patients with a history of CHD were asked to identify possible symptoms of heart attack. Despite their history of CHD, 44% had low knowledge levels. Among these high-risk participants, 43% underestimated their risk for a future AMI (men 47%, women 36%).[27]
- Data from Worcester, MA, indicate that the average time from symptom onset to hospital arrival has not improved and that delays in hospital arrival are associated with less receipt of guidelines-based care. Mean and median prehospital delay times from symptom onset to arrival at the hospital were 4.1 and 2.0 hours in 1986 and 4.6 and 2.0 hours in 2005, respectively. Receipt of thrombolytic therapy and PCI within 90 minutes of hospital arrival was less likely among patients who arrived within ≥2 hours of symptom onset than among those who arrived <2 hours after onset.[28]
- In an analysis from ARIC, low neighborhood household income (OR, 1.46; 95% CI, 1.09–1.96) and being a Medicaid recipient (OR, 1.87; 95% CI, 1.10–3.19) were associated with increased odds of having prolonged prehospital delays from symptom onset to hospital arrival for AMI compared with individuals with higher neighborhood household income and other insurance providers, respectively.[29]
- An analysis of data from the NCDR ACTION Registry–GWTG showed that 60% of 37 634 STEMI patients used EMS to get to the hospital. Older adults, women, adults with comorbidities, and sicker patients were more likely to use EMS than their counterparts. Hospital arrival time was shorter for those who used EMS (89 minutes) than self-transport (120 minutes).[30]

Aftermath

- Depending on their sex and clinical outcome, people who survive the acute stage of an MI have a chance of illness and death 1.5 to 15 times higher than that of the general population. Among these people, the risk of another MI, sudden death, AP, HF, and stroke—for both men and women—is substantial (FHS, NHLBI).[5]
- On the basis of pooled data from the FHS, ARIC, CHS, MESA, CARDIA, and JHS studies of the NHLBI (1995–2012), within 1 year after a first MI:
  - —At ≥45 years of age, 18% of men and 23% of women will die.
  - —At 45 to 64 years of age, 3% of white men, 5% of white women, 9% of black men, and 10% of black women will die.
  - —At 65 to 74 years of age, 14% of white men, 18% of white women, 22% of black men, and 21% of black women will die.
  - —At ≥75 years of age, 27% of white men, 29% of white women, 19% of black men, and 31% of black women will die.
  - —In part because women have MIs at older ages than men, they are more likely to die of MI within a few weeks.
- Within 5 years after a first MI:
  - —At ≥45 years of age, 36% of men and 47% of women will die.
  - —At 45 to 64 years of age, 11% of white men, 17% of white women, 16% of black men, and 28% of black women will die.
  - —At 65 to 74 years of age, 25% of white men, 30% of white women, 33% of black men, and 44% of black women will die.
  - —At ≥75 years of age, 55% of white men, 60% of white women, 61% of black men, and 64% of black women will die.
- Of those who have a first MI, the percentage with a recurrent MI or fatal CHD within 5 years is as follows:
  - —At ≥45 years of age, 17% of men and 21% of women
  - —At 45 to 64 years of age, 11% of white men, 15% of white women, 22% of black men, and 32% of black women
  - —At 65 to 74 years of age, 12% of white men, 17% of white women, 30% of black men, and 30% of black women
  - —At ≥75 years of age, 21% of white men, 20% of white women, 45% of black men, and 20% of black women
- The percentage of people with a first MI who will have HF in 5 years is as follows:
  - —At >45 years of age, 16% of men and 22% of women
  - —At 45 to 64 years of age, 6% of white men, 10% of white women, 13% of black men, and 25% of black women
  - —At 65 to 74 years of age, 12% of white men, 16% of white women, 20% of black men, and 32% of black women
  - —At ≥75 years of age, 25% of white men, 27% of white women, 23% of black men, and 19% of black women
- The percentage of people with a first MI who will have an incident stroke within 5 years is as follows:
  - —At >45 years of age, 4% of men and 7% of women
  - —At >45 years of age, 5% of white men, 6% of white women, 4% of black men, and 10% of black women

- The median survival time (in years) after a first MI is as follows:
  - —At ≥45 years of age, 8.2 for men and 5.5 for women
  - —At >45 years of age, 8.4 for white men, 5.6 for white women, 7.0 for black men, and 5.5 for black women
- An analysis of Medicare claims data revealed that only 13.9% of Medicare beneficiaries enroll in cardiac rehabilitation after an AMI, and only 31% enroll after CABG. Older people, women, nonwhites, and individuals with comorbidities were less likely to enroll in cardiac rehabilitation programs.[31]
- In a community-based analysis of residents in Olmstead County, MN, discharged with first MI between 1987 and 2010, 52.5% participated in cardiac rehabilitation. The overall rate of participation did not change during the study period. Cardiac rehabilitation was associated with reductions in all-cause mortality and readmission.[32]

Hospital Discharges and Ambulatory Care Visits

(See Table 19-1 and Chart 19-8.)

- From 2000 to 2010, the number of inpatient discharges from short-stay hospitals with CHD as the first-listed diagnosis decreased from 2 165 000 to 1 346 000 (NHDS, NHLBI tabulation).
- In 2012, there were 8 953 000 physician office visits for CHD (NAMCS, NHLBI tabulation). In 2011, there were 463 000 ED visits and 691 000 outpatient department visits with a primary diagnosis of CHD (NHAMCS, NHLBI tabulation).
- Total office visits for angina declined from 3.6 million per year in 1995 to 1998 to 2.3 million per year in 2007 to 2010, based on data from the NAMCS and the NHAMCS.[33]

Operations and Procedures

- In 2010, an estimated 954 000 inpatient PCI procedures, 397 000 inpatient bypass procedures, 1 029 000 inpatient diagnostic cardiac catheterizations, 97 000 inpatient implantable defibrillator procedures, and 370 000 pacemaker procedures were performed for inpatients in the United States (NHLBI tabulation).
- An analysis of data from HCUP showed that between 2001 and 2008, there had been a 15% decrease in the annual rate of coronary revascularization, primarily attributable to declines in CABG (1742 procedures per million in 2001–2002 versus 1081 procedures per million in 2007–2008). Rates of PCI did not change significantly over the same period.[34]
- However, in Massachusetts, age- and sex-adjusted rates of coronary revascularization (PCI or CABG) declined from 423 to 258 per 100 000 residents (39% decline) between 2003 and 2012. Rates of elective PCI declined by 50% over the period, whereas rates of PCI in the setting of MI declined by 16%.[35,36]
- Among Medicare fee-for-service beneficiaries, the total number of revascularization procedures performed peaked in 2010 and declined by >4% per year through 2012. In-hospital and 90-day mortality rates declined after CABG surgery overall, as well as among patients presenting for elective CABG or CABG after NSTEMI.[36]
- Among patients presenting for PCI after STEMI in the NCDR, D2B time decreased from 83 to 67 minutes between 2005 and 2009; however, there was no significant change in unadjusted or adjusted in-hospital or 30-day mortality rates during the same time period.[37]

Cost

(See Table 19-1.)

- The estimated direct and indirect cost of HD in 2011 to 2012 (average annual) was $207.3 billion (MEPS, NHLBI tabulation).
- MI ($11.5 billion) and CHD ($10.4 billion) were 2 of the 10 most expensive hospital principal discharge diagnoses in 2011.[38]
- Between 2013 and 2030, medical costs of CHD (real 2010$) are projected to increase by ≈100%
  - —Indirect costs for all CVD (real 2010$) are projected to increase 52% (from $202.5 billion to $308.2 billion) between 2013 and 2030. Of these indirect costs, CHD is projected to account for ≈43% and has the largest indirect costs (AHA computation, based on methodology described by Heidenreich et al[3]).

Acute Coronary Syndrome

ICD-9 410, 411; ICD-10 I20.0, I21, I22.

The term *ACS* includes the diagnoses of AMI (STEMI or NSTEMI) and UA. UA is chest pain or discomfort that is accelerating in frequency or severity and may occur while at rest but does not result in myocardial necrosis. The discomfort may be more severe and prolonged than typical stable AP, or it may be the first time a person has had AP. UA, NSTEMI, and STEMI share common pathophysiological origins related to coronary plaque progression, instability, or rupture with or without luminal thrombosis and vasospasm.

- A conservative estimate for the number of discharges with ACS from hospitals in 2010 is 625 000. Of these, an estimated 363 000 are males and 262 000 are females. This estimate is derived by adding the first-listed inpatient hospital discharges for MI (595 000) to those for UA (30 000; NHDS, NHLBI).
- When secondary discharge diagnoses in 2010 were included, the corresponding number of inpatient hospital discharges was 1 141 000 unique hospitalizations for ACS; 653 000 were males, and 488 000 were females. Of the total, 813 000 were for MI alone, 322 000 were for UA alone, and 6000 hospitalizations received both diagnoses (NHDS, NHLBI).
- Among commercially insured adults 18 to 64 years of age, the 1-year medical costs for an ACS event during 2004 to 2005 were $34 087 for those who were treated with medical management, $52 673 for those who were treated with percutaneous intervention, and $86 914 for those who had CABG. The 1-year short-term disability costs were $6048, $9221, and $17 335, respectively, and the 1-year absenteeism costs were $9826, $9460, and $14 960, respectively.[39] Another study of the same database using adults 18 to 64 years of age who had a principal inpatient diagnosis of ACS during 2003 to 2006 estimated that the incremental annual

direct cost was $40 671 and the incremental short-term disability cost was $999.[40]

Decisions about medical and interventional treatments are based on specific findings noted when a patient presents with ACS. Such patients are classified clinically into 1 of 3 categories according to the presence or absence of ST-segment elevation on the presenting ECG and abnormal ("positive") elevations of myocardial biomarkers, such as troponins, as follows:

- STEMI
- NSTEMI
- UA

The percentage of ACS or MI cases with ST-segment elevation varies in different registries/databases and depends heavily on the age of patients included and the type of surveillance used. According to NRMI-4, ≈29% of patients with MI are patients with STEMI.[41] The AHA GWTG project found that 32% of the patients with MI in the CAD module were patients with STEMI (personal communication from AHA GWTG staff, October 1, 2007). The GRACE study, which includes US patient populations, found that 38% of ACS patients have STEMI, whereas the EHS-ACS-II reported that ≈47% of patients with ACS have STEMI.[42]

In addition, the percentage of ACS or MI cases with ST-segment elevation appears to be declining. In an analysis of 46 086 hospitalizations for ACS in the Kaiser Permanente Northern California study, the percentage of MI cases with ST-segment elevation decreased from 47.0% to 22.9% between 1999 and 2008.[8]

- Analysis of data from the GRACE multinational observational cohort study of patients with ACS found evidence of a change in practice for both pharmacological and interventional treatments in patients with either STEMI or non–ST-segment–elevation ACS. These changes have been accompanied by nonsignificant decreases in the rates of in-hospital death, cardiogenic shock, and new MI among patients with non–ST-segment–elevation ACS. The use of evidence-based therapies and PCI interventions increased in the STEMI population. This increase was matched by a statistically significant decrease in the rates of death, cardiogenic shock, and HF or pulmonary edema.[43]
- A study of hospital process performance in 350 centers of nearly 65 000 patients enrolled in the CRUSADE National Quality Improvement Initiative found that ACC/AHA guideline–recommended treatments were adhered to in 74% of eligible instances.[44] A better composite guideline adherence rate was significantly associated with decreased in-hospital mortality among all patients with ACS and those with NSTEMI.
- After adjustment for clinical differences and the severity of CAD by angiogram, 30-day mortality after ACS is similar in men and women.[45]

Stable AP

ICD-9 413; ICD-10 I20.1 to I20.9.

Prevalence

(See Table 19-2 and Charts 19-9 to 19-10.)

- A study of 4 national cross-sectional health examination studies found that among Americans 40 to 74 years of age, the age-adjusted prevalence of AP was higher among women than men. Increases in the prevalence of AP occurred for Mexican American men and women and African American women but were not statistically significant for the latter.[46]
- On the basis of data from NHANES from 1998 to 2004 and the six 2-year surveys from 2001 to 2012, in 2009 to 2012, there were an average of 3.4 million people ≥40 years of age in the United States with angina each year compared with 4 million in 1988 to 1994. Declines in angina symptoms have occurred for whites but not for blacks.[47]

Incidence

(See Table 19-2 and Chart 19-11.)

- Only 18% of coronary attacks are preceded by long-standing AP (NHLBI computation of FHS follow-up since 1986).
- The annual rates per 1000 population of new episodes of AP for nonblack men are 28.3 for those 65 to 74 years of age, 36.3 for those 75 to 84 years of age, and 33.0 for those ≥85 years of age. For nonblack women in the same age groups, the rates are 14.1, 20.0, and 22.9, respectively. For black men, the rates are 22.4, 33.8, and 39.5, and for black women, the rates are 15.3, 23.6, and 35.9, respectively (CHS, NHLBI).[48]

Cost

- For women with nonobstructive CHD enrolled in the WISE study of the NHLBI, the average lifetime cost estimate was ≈$770 000 and ranged from $1.0 to $1.1 million for women with 1- to 3-vessel CHD.[49]

Table 19-1. Coronary Heart Disease

Population Group	Prevalence, CHD, 2012 Age ≥20 y	Prevalence, MI, 2012 Age ≥20 y	New and Recurrent MI and Fatal CHD, Age ≥35 y	New and Recurrent MI, Age ≥35 y	Mortality,* CHD, 2013 All Ages	Mortality,* MI, 2013 All Ages	Hospital Discharges CHD, 2010 All Ages
Both sexes	15 500 000 (6.2%)	7 600 000 (2.8%)	965 000	750 000	370 213	116 793	1 346 000
Males	8 900 000 (7.6%)	4 900 000 (4.0%)	560 000	440 000	208 515 (56.3%)†	66 051 (56.6%)†	828 000
Females	6 600 000 (5.0%)	2 700 000 (1.8%)	405 000	310 000	161 698 (43.7%)†	50 742 (43.4%)†	518 000
NH white males	7.8%	4.1%	480 000‡	…	168 228	53 434	…
NH white females	4.6%	1.8%	340 000‡	…	129 273	40 461	…
NH black males	7.2%	3.4%	80 000‡	…	20 758	6456	…
NH black females	7.0%	2.2%	65 000‡	…	18 441	6004	…
Hispanic males	6.7%	3.5%	…	…	12 518	4099	…
Hispanic females	5.9%	1.7%	…	…	9270	2858	…
NH Asian or Pacific Islander	…	…	…	…	8477§	2616§	…
NH American Indian or Alaska Native	6.0%‖¶	…	…	…	1949	589	…

CHD includes people who responded "yes" to at least 1 of the questions in "Has a doctor or other health professional ever told you that you had coronary heart disease, angina or angina pectoris, heart attack, or myocardial infarction?" Those who answered "no" but were diagnosed with Rose angina are also included (the Rose questionnaire is only administered to survey participants >40 years of age).

CHD indicates coronary heart disease; ellipses (…), data not available; MI, myocardial infarction; and NH, non-Hispanic.

*Mortality for Hispanic, American Indian or Alaska Native, and Asian and Pacific Islander people should be interpreted with caution because of inconsistencies in reporting Hispanic origin or race on the death certificate compared with censuses, surveys, and birth certificates. Studies have shown underreporting on death certificates of American Indian or Alaska Native, Asian and Pacific Islander, and Hispanic decedents, as well as undercounts of these groups in censuses.

†These percentages represent the portion of total CHD and MI mortality that is for males vs females.

‡Estimates include Hispanics and non-Hispanics. Estimates for whites include other nonblack races.

§Includes Chinese, Filipino, Hawaiian, Japanese, and Other Asian or Pacific Islander.

‖National Health Interview Survey, National Center for Health Statistics 2014; data are weighted percentages for Americans ≥18 years of age.[1]

¶Estimate considered unreliable or does not meet standards of reliability or precision.

Sources: Prevalence: National Health and Nutrition Examination Survey 2009 to 2012 (National Center for Health Statistics) and National Heart, Lung, and Blood Institute. Percentages for racial/ethnic groups are age adjusted for Americans ≥20 years of age. Age-specific percentages are extrapolated to the 2012 US population estimates. These data are based on self-reports. Incidence: Atherosclerosis Risk in Communities study (2005–2012), National Heart, Lung, and Blood Institute. Mortality: Centers for Disease Control and Prevention/National Center for Health Statistics, 2013 Mortality Multiple Cause-of-Death–United States. Hospital discharges: National Hospital Discharge Survey, National Center for Health Statistics (data include those inpatients discharged alive, dead, or status unknown).

Table 19-2. Angina Pectoris

Population Group	Prevalence, 2012, Age ≥20 y	Incidence of Stable AP, Age ≥45 y	Hospital Discharges, 2010, All Ages*
Both sexes	8 200 000 (3.3%)	565 000	22 000
Males	4 000 000 (3.4%)	370 000	12 000
Females	4 200 000 (3.2%)	195 000	10 000
NH white males	3.4%	…	…
NH white females	2.9%	…	…
NH black males	3.3%	…	…
NH black females	5.0%	…	…
Hispanic males	3.2%	…	…
Hispanic females	3.8%	…	…

AP is chest pain or discomfort that results from insufficient blood flow to the heart muscle. Stable AP is predictable chest pain on exertion or under mental or emotional stress. The incidence estimate is for AP without myocardial infarction.

AP indicates angina pectoris; ellipses, data not available; and NH, non-Hispanic.

*There were 56 000 days of care for discharges of patients with AP from short-stay hospitals in 2010.

Sources: Prevalence: National Health and Nutrition Examination Survey 2009 to 2012 (National Center for Health Statistics) and National Heart, Lung, and Blood Institute; percentages for racial/ethnic groups are age adjusted for US adults ≥20 years of age. AP includes people who either answered "yes" to the question of ever having angina or AP or who were diagnosed with Rose angina (the Rose questionnaire is only administered to survey participants >40 years of age). Estimates from National Health and Nutrition Examination Survey 2009 to 2012 (National Center for Health Statistics) were applied to 2010 population estimates (≥20 years of age). Incidence: AP uncomplicated by a myocardial infarction or with no myocardial infarction (Framingham Heart Study [the original cohort and the Offspring Cohort 1986–2009], National Heart, Lung, and Blood Institute). Hospital discharges: National Hospital Discharge Survey, National Center for Health Statistics; data include those inpatients discharged alive, dead, or status unknown.

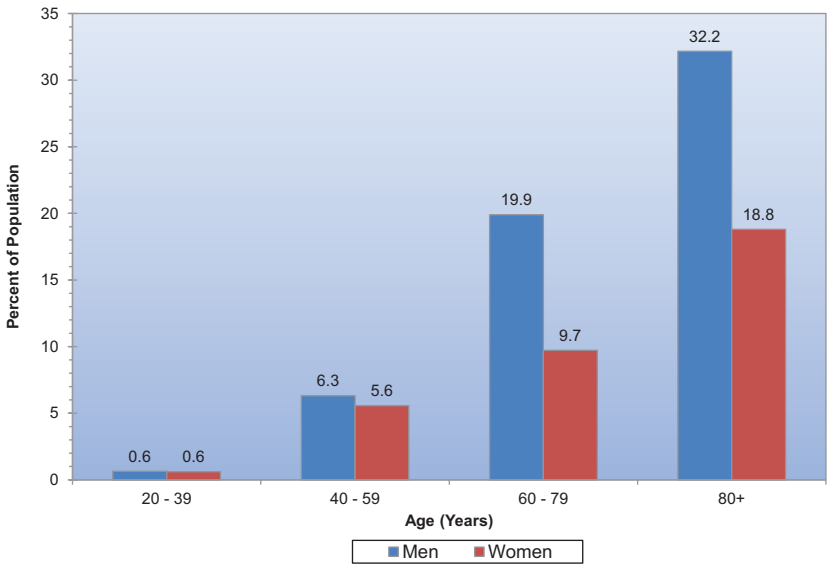


Chart 19-1. Prevalence of coronary heart disease by age and sex (National Health and Nutrition Examination Survey: 2009–2012). Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

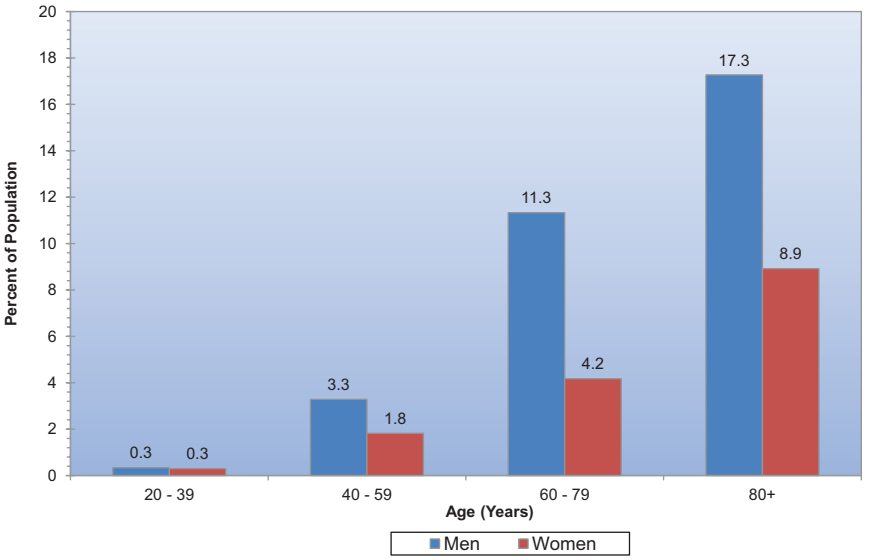


Chart 19-2. Prevalence of myocardial infarction by age and sex (National Health and Nutrition Examination Survey: 2009–2012). Myocardial infarction includes people who answered "yes" to the question of ever having had a heart attack or myocardial infarction. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

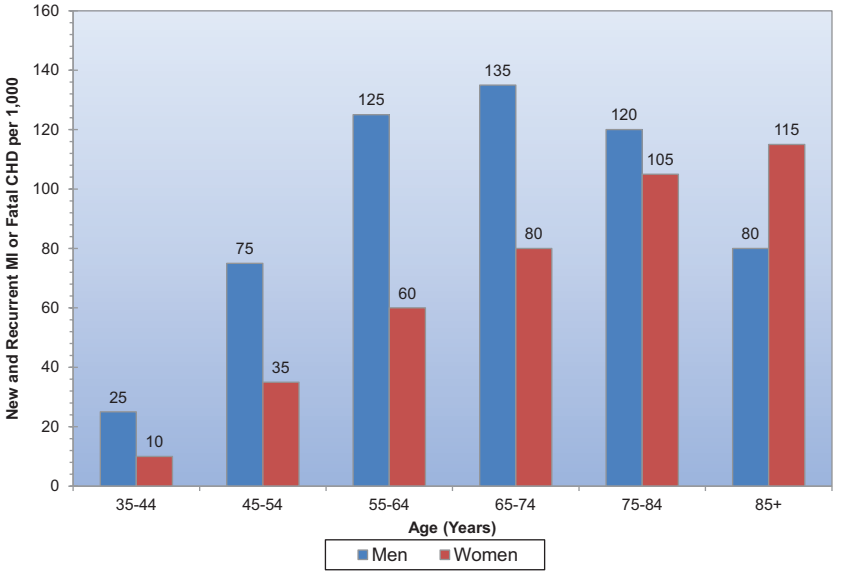


Chart 19-3. Annual number of adults per 1000 having diagnosed heart attack or fatal coronary heart disease (CHD) by age and sex (Atherosclerosis Risk in Communities Surveillance: 2005–2011 and Cardiovascular Health Study). These data include myocardial infarction (MI) and fatal CHD but not silent MI. Source: National Heart, Lung, and Blood Institute.

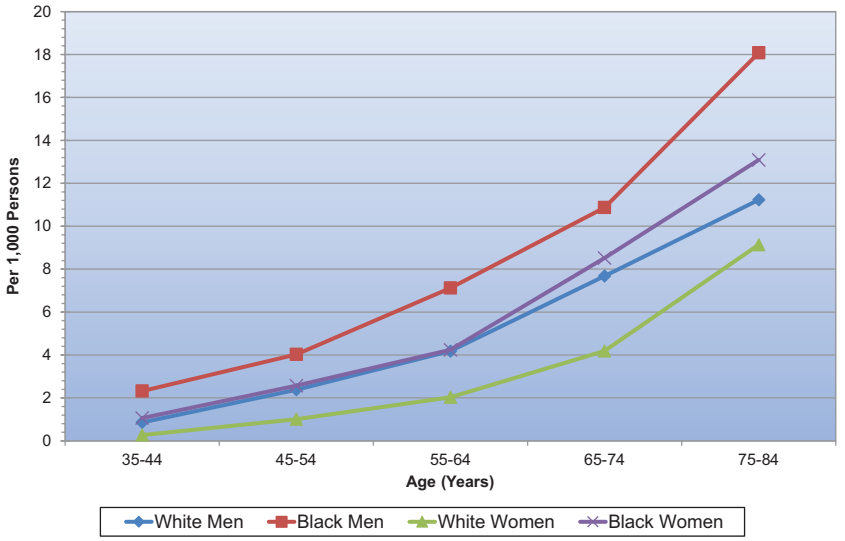


Chart 19-4. Incidence of heart attack or fatal coronary heart disease by age, sex, and race (Atherosclerosis Risk in Communities Surveillance: 2005–2011). Source: National Heart, Lung, and Blood Institute.

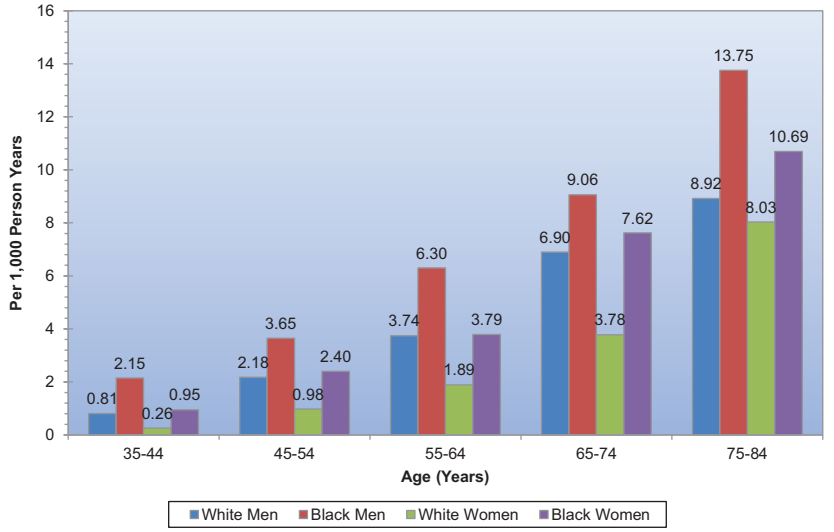
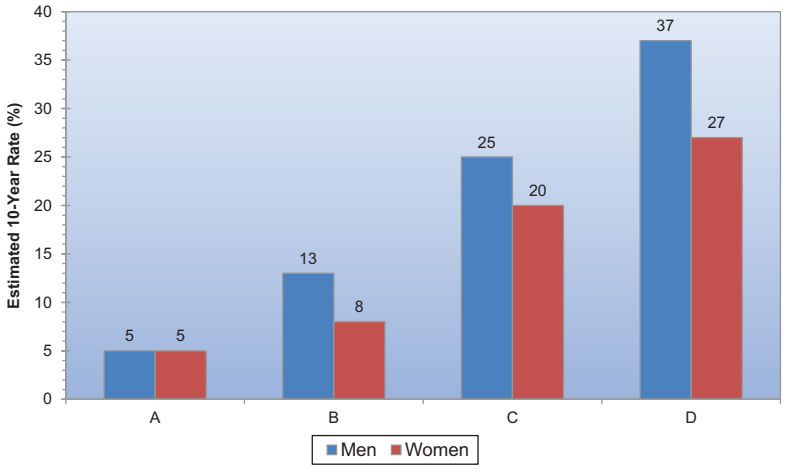


Chart 19-5. Incidence of myocardial infarction by age, sex, and race (Atherosclerosis Risk in Communities Surveillance: 2005-2011). Source: Unpublished data from Atherosclerosis Risk in Communities study, National Heart, Lung, and Blood Institute.



	A	B	C	D
Blood Pressure	120/80	140/90	140/90	140/90
Cholesterol	200	240	240	240
HDL-C	50	50	40	40
Diabetes	No	No	Yes	Yes
Cigarettes	No	No	No	Yes

Chart 19-6. Estimated 10-year coronary heart disease risk in adults 55 years of age according to levels of various risk factors (Framingham Heart Study). HDL-C indicates high-density lipoprotein cholesterol. Data derived from Wilson et al.[50]

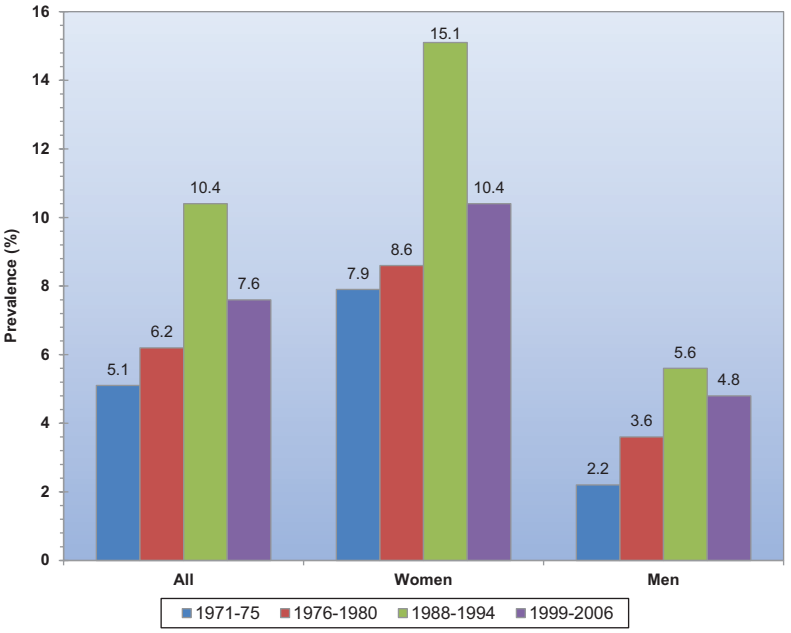


Chart 19-7. Prevalence of low coronary heart disease risk, overall and by sex (National Health and Nutrition Examination Survey: 1971–2006). Low risk is defined as systolic blood pressure <120 mm Hg and diastolic blood pressure <80 mm Hg; cholesterol <200 mg/dL; body mass index <25 kg/m^2; currently not smoking cigarettes; and no prior myocardial infarction or diabetes mellitus. Source: Personal communication with the National Heart, Lung, and Blood Institute, June 28, 2007.

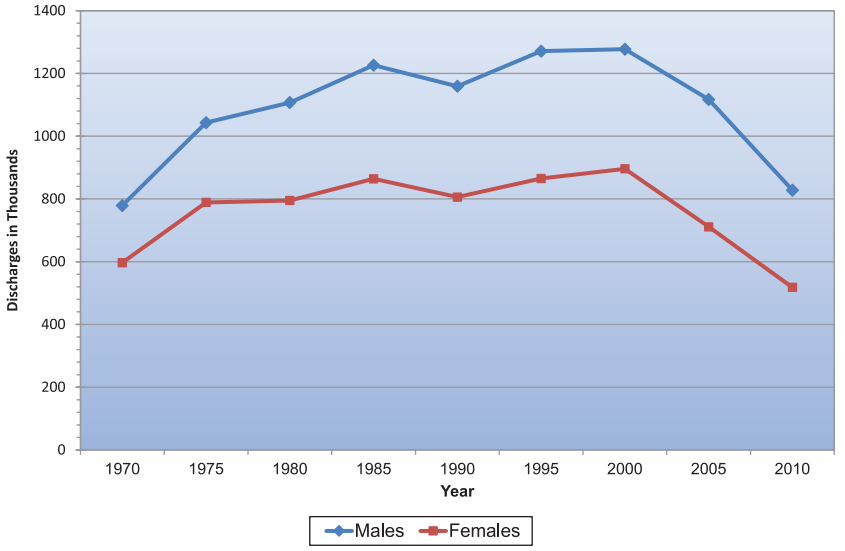


Chart 19-8. Hospital discharges for coronary heart disease by sex (United States: 1970–2010). Hospital discharges include people discharged alive, dead, and "status unknown." Source: National Hospital Discharge Survey/National Center for Health Statistics and National Heart, Lung, and Blood Institute.

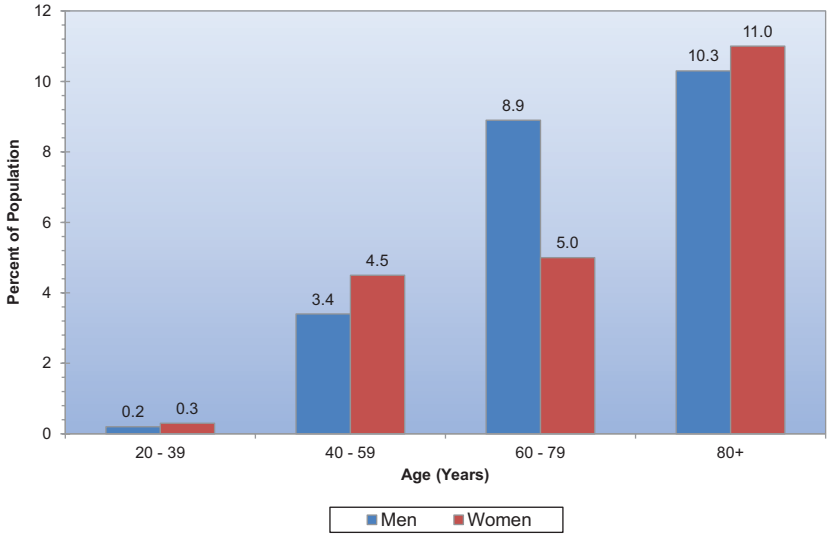


Chart 19-9. Prevalence of angina pectoris by age and sex (National Health and Nutrition Examination Survey: 2009–2012). Angina pectoris includes people who either answered "yes" to the question of ever having angina or angina pectoris or were diagnosed with Rose Angina. Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

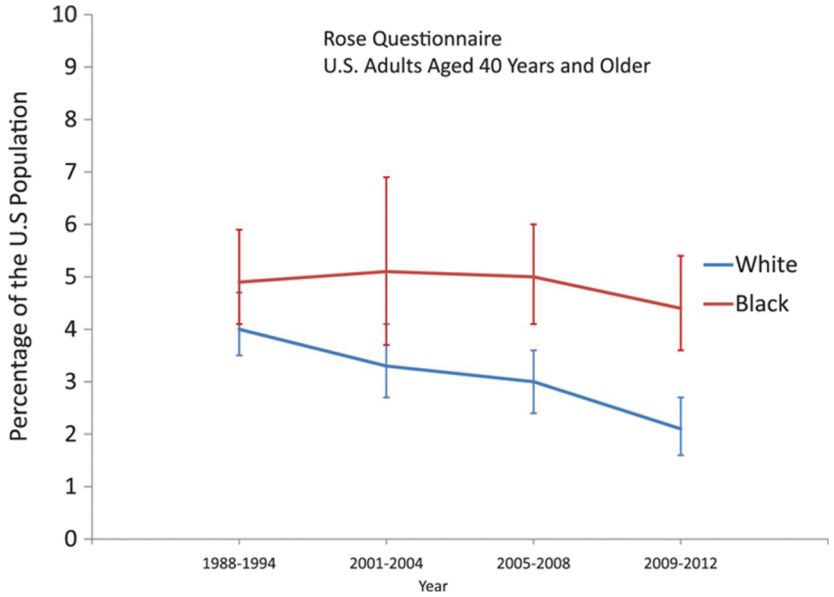


Chart 19-10. Secular trends in age-and sex-standardized prevalence rates of angina for adults aged ≥40 years in the United States, by race, for angina symptoms defined using the Rose questionnaire. Reprinted from Will et al with permission.[47] Copyright © 2014, American Heart Association, Inc.

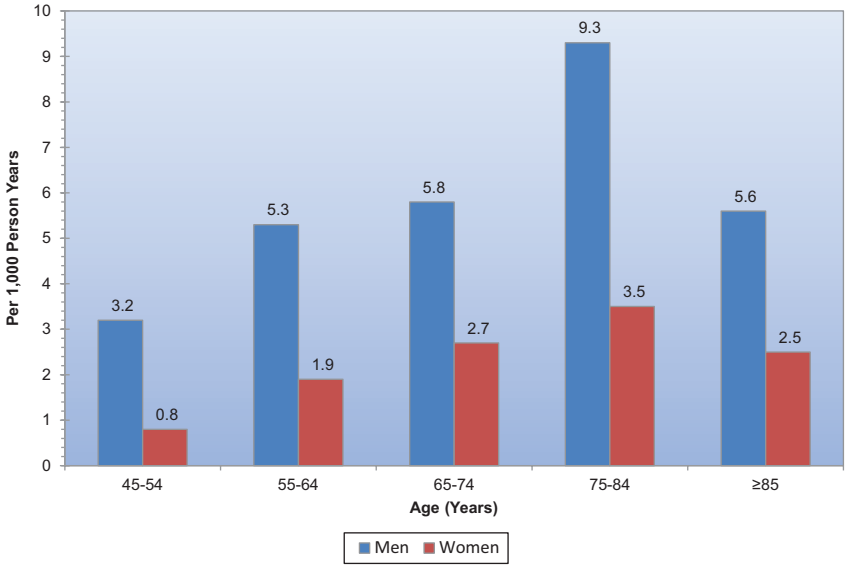


Chart 19-11. Incidence of angina pectoris (deemed uncomplicated on the basis of physician interview of patient) by age and sex (Framingham Heart Study 1986–2009). Data derived from National Heart, Lung, and Blood Institute.

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20. Cardiomyopathy and Heart Failure

See Table 20-1 and Charts 20-1 through 20-4.

Cardiomyopathy

ICD-9 425; ICD-10 I42.

Mortality—23 080. Any-mention mortality—46 228. Hospital discharges—34 000.

Youth

(See Chart 20-1.)

- Since 1996, the NHLBI-sponsored Pediatric Cardiomyopathy Registry has collected data on all children with newly diagnosed cardiomyopathy in New England and the Central Southwest (Texas, Oklahoma, and Arkansas).[1]
  - —The overall incidence of cardiomyopathy is 1.13 cases per 100 000 among children <18 years of age.
  - —Among children <1 year of age, the incidence is 8.34, and among children 1 to 18 years of age, it is 0.70 per 100 000.
  - —The annual incidence is lower in white than in black children, higher in boys than in girls, and higher in New England (1.44 per 100 000) than in the Central Southwest (0.98 per 100 000).
- Dilated cardiomyopathy is the most common form of cardiomyopathy among children. The Pediatric Cardiomyopathy Registry recently reported an annual incidence of dilated cardiomyopathy in children <18 years of age of 0.57 per 100 000 overall. The annual incidence was higher in boys than in girls (0.66 versus 0.47 cases per 100 000), in blacks than in whites (0.98 versus 0.46 cases per 100 000), and in infants (<1 year of age) than in children (4.40 versus 0.34 cases per 100 000). The majority of children (66%) had idiopathic disease. The most common known causes of dilated cardiomyopathy were myocarditis (46%) and neuromuscular disease (26%).[2] Risk factors for death and transplantation in children varied according to cause of dilated cardiomyopathy. For idiopathic dilated cardiomyopathy, increased LV end-diastolic dimension was associated with increased risk for transplantation but not mortality. Short stature was significantly related to death but not transplantation.[3]
- HCM is the most common inherited heart defect, occurring in 1 of 500 individuals. In the United States, ≈500 000 people have HCM, yet most are unaware of it.[4] In a recent report of the Pediatric Cardiomyopathy Registry, the overall annual incidence of HCM in children was 4.7 per 1 million children. There was a higher incidence in the New England than in the Central Southwest region, in boys than in girls, and in children diagnosed at <1 year of age than in older children.[5] The 5-year incidence rate of sudden cardiac death among children with dilated cardiomyopathy is 3%.[6] See Chapter 16, Disorders of Heart Rhythm, for statistics regarding sudden death in HCM.
- Data from Kaiser Permanente indicate that the incidence of peripartum cardiomyopathy is 4.84 per 10 000 live births (95% CI, 3.98–5.83), and peripartum cardiomyopathy is associated with higher maternal and neonatal death rates and worse neonatal outcomes.[7] There was a trend toward an increase in the incidence of peripartum cardiomyopathy in the United States from 1990 through 1993 to 2000 through 2002, which suggests this might be related to a rise in maternal age.[8]

Global Burden of Cardiomyopathy

- Between 1990 and 2010, the global number of deaths attributed to cardiomyopathy and myocarditis increased 40.8%,

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Abbreviations Used in Chapter 20

ABC	Health, Aging, and Body Composition Study	HCM	hypertrophic cardiomyopathy
ACEI	angiotensin-converting enzyme inhibitor	HD	heart disease
ADHERE	Acute Decompensated Heart Failure Registry	HF	heart failure
ARIC	Atherosclerosis Risk in Communities Study	HR	hazard ratio
BMI	body mass index	*ICD-10*	*International Classification of Diseases, 10th Revision*
BNP	B-type natriuretic peptide	*ICD-9*	*International Classification of Diseases, 9th Revision*
BP	blood pressure	LV	left ventricular
CAD	coronary artery disease	MESA	Multi-Ethnic Study of Atherosclerosis
CARDIA	Coronary Artery Risk Development in Young Adults Study	MI	myocardial infarction
CHD	coronary heart disease	NAMCS	National Ambulatory Medical Care Survey
CHS	Cardiovascular Health Study	NCHS	National Center for Health Statistics
CI	confidence interval	NH	non-Hispanic
CRP	C-reactive protein	NHAMCS	National Hospital Ambulatory Medical Care Survey
CVD	cardiovascular disease	NHANES	National Health and Nutrition Examination Survey
DM	diabetes mellitus	NHDS	National Hospital Discharge Survey
ED	emergency department	NHLBI	National Heart, Lung, and Blood Institute
EF	ejection fraction	PA	physical activity
FHS	Framingham Heart Study	PAR	population attributable risk
HbA_{1c}	hemoglobin A_{1c} (glycosylated hemoglobin)	RR	relative risk
HBP	high blood pressure	SBP	systolic blood pressure

from 286 800 to 403 900, but the age-standardized death rate decreased 9.8%, from 6.7 to 6.1 per 100 000.[9] However, between 1990 and 2010, the global years lived with disability for cardiomyopathy and myocarditis increased 11.4%, from 5 to 6 years lived with disability per 100 000.[10] The reported incidence of peripartum cardiomyopathy in the United States varies considerably, whereas the reported incidences in several African and Asian countries are similar.

Heart Failure

ICD-9 428; ICD-10 I50.

Prevalence

(See Table 20-1 and Chart 20-2.)

- On the basis of data from NHANES 2009 to 2012, an estimated 5.7 million Americans ≥20 years of age had HF (NHLBI tabulation).
- Projections show that the prevalence of HF will increase 46% from 2012 to 2030, resulting in >8 million people ≥18 years of age with HF.[11]

Incidence

(See Table 20-1 and Chart 20-3.)

- On the basis of data from the community surveillance component of the ARIC study of the NHLBI:
  - —There are 915 000 new HF cases annually (ARIC 2005–2012; based on community trends in the occurrence of hospitalized HF and case fatality; unpublished report for the NHLBI.)
  - —At ages <75 years, HF incidence is higher in blacks than whites.
- Data from the NHLBI-sponsored FHS[12] indicate the following:
  - —HF incidence approaches 10 per 1000 population after 65 years of age.
  - —Seventy-five percent of HF cases have antecedent hypertension.
  - —At 40 years of age, the lifetime risk of developing HF for both men and women is 1 in 5.
  - —At 80 years of age, remaining lifetime risk for development of new HF remains at 20% for men and women, even in the face of a much shorter life expectancy.
  - —At 40 years of age, the lifetime risk of HF occurring without antecedent MI is 1 in 9 for men and 1 in 6 for women.
  - —The lifetime risk for people with BP >160/90 mm Hg is double that of those with BP <140/90 mm Hg.
- In the FHS (1980–2003), the annual rates per 1000 person-years of new HF events for white men were 9.2 for those 65 to 74 years of age, 22.3 for those 75 to 84 years of age, and 43.0 for those ≥85 years of age. For white women in the same age groups, the rates were 4.7, 14.8, and 30.7, respectively. Thus, HF incidence rates in men approximately double with each 10-year age increase from 65 to 85 years; however, the HF incidence rate triples for women between ages 65 to 74 and 75 to 84 years.[13]
- In MESA, African Americans had the highest risk of developing HF, followed by Hispanic, white, and Chinese Americans (4.6, 3.5, 2.4, and 1.0 per 1000 person-years, respectively). This higher risk reflected differences in the prevalence of hypertension, DM, and low socioeconomic status.[14]
- African Americans had the highest proportion of incident HF not preceded by clinical MI (75%).[14]
- In the NHLBI's ARIC study, the age-adjusted incidence rate per 1000 person-years was 3.4 for white women, less than for all other groups, that is, white men (6.0), black women (8.1), and black men (9.1). The 30-day, 1-year, and 5-year case fatality rates after hospitalization for HF were 10.4%, 22%, and 42.3%, respectively. Blacks had a greater 5-year case fatality rate than whites ($P<0.05$). HF incidence rates in black women were more similar to those of men than of white women. The greater HF incidence in blacks than in whites is explained largely by blacks' greater levels of atherosclerotic risk factors.[15]
- Data from Kaiser Permanente indicated an increase in the incidence of HF among the elderly and improved HF survival, resulting in increased HF prevalence, with both effects being greater in men.[16]
- Data from hospitals in Worcester, MA, indicate that during 2000, the incidence rates for HF were 219 per 100 000. HF was more frequent in women and the elderly.[17]
- Data from Olmsted County, MN, indicate that the age- and sex-adjusted incidence of HF declined substantially from 315.8 per 100 000 in 2000 to 219.3 per 100 000 in 2010, with a greater rate reduction for HF with reduced EF (−45.1%; 95% CI, −33.0% to −55.0%) than for HF with preserved EF (−27.9%; 95% CI, −12.9% to −40.3%).[18]
- In the CARDIA study, HF before 50 years of age was more common among blacks than whites. Hypertension, obesity, and systolic dysfunction are important risk factors that may be targets for prevention.[19]
- The lifetime risks of HF were assessed in a large group of 39 578 participants from several cohorts (Chicago Heart Association Detection Project in Industry, ARIC, and CHS). At age 45 years, lifetime risks for HF through age 75 or 95 years were 30% to 42% in white men, 20% to 29% in black men, 32% to 39% in white women, and 24% to 46% in black women. HBP and higher BMI at all ages in both blacks and whites led to higher lifetime risks.[20]

Mortality

(See Table 20-1.)

- One in 9 deaths has HF mentioned on the death certificate (NCHS, NHLBI).[21]
- In 2013, HF any-mention mortality was 300 122 (140 126 males and 159 996 females). HF was the underlying cause in 65 120 of those deaths in 2013.[21] Table 20-1 shows the numbers of these deaths that were coded for HF as the underlying cause.
- The 2013 overall any-mention death rate for HF was 83.4. Any-mention death rates in males were 101.9 for non-Hispanic whites, 105.4 for non-Hispanic blacks, 48.2 for non-Hispanic Asians or Pacific Islanders, 99.2 for non-Hispanic American Indians or Alaska Natives, and 63.8 for Hispanics. In females, the respective death rates were 75.0 for

non-Hispanic whites, 80.3 for non-Hispanic blacks, 33.1 for non-Hispanic Asians or Pacific Islanders, 73.0 for non-Hispanic American Indians or Alaska Natives, and 47.7 for Hispanics.[21]

- The number of any-mention deaths attributable to HF was approximately as high in 1995 (287 000) as it was in 2013 (300 000; NCHS, NHLBI).[21]
- Survival after HF diagnosis has improved between 1979 and 2000, as shown by data from the Olmsted County Study.[22] However, the death rate remains high: ≈50% of people diagnosed with HF will die within 5 years.[22,23]
- In the elderly, data from Kaiser Permanente indicate that survival after the onset of HF has also improved.[16]
- In the CHS, both the presence of depression and elevated N-terminal pro-BNP levels were independent risk factors that identified HF patients with a high risk of all-cause mortality.[24]
- Among Medicare beneficiaries, the overall 1-year HF mortality rate declined slightly from 1998 to 2008 but remained high at 29.6%.[25] Rates of mortality decline were uneven across states.
- Recent data from Olmsted County, MN, reveal that among incident HF cases, 5-year mortality did not decline from 2000 to 2010. Five-year mortality remained high (52.6% overall; 24.4% for 60-year-olds and 54.4% for 80-year-olds) and was more frequently ascribed to noncardiovascular causes (54.3%); however, the risk of noncardiovascular death was greater in HF with preserved EF than in HF with reduced EF.[18]
- Mortality declines have been primarily attributed to evidence-based approaches to treat HF risk factors and implementation of ACEIs, β-blockers, coronary revascularization, implantable cardioverter-defibrillators, and cardiac resynchronization therapeutic strategies.[26]

Global Burden of HF

- HF is common throughout sub-Saharan Africa. Forty-four percent of patients with newly diagnosed CVD have HF, whereas only 10% have CAD.[27] Common causes include nonischemic cardiomyopathies, rheumatic heart disease, congenital heart disease, hypertensive heart disease, and endomyocardial fibrosis; ischemic HD remains relatively uncommon. HF strikes individuals in sub-Saharan Africa at a much younger age than in the United States and Europe.[28] The prevalence estimates for HF across Asia range from 1.26% to 6.7%. Rheumatic heart disease is a major contributor to HF in certain parts of South Asia, such as India, but recently, trends toward an ischemic cause for HF have been observed in Asia, such as in China and Japan.[29]
- For men, HF prevalence in 2010 was highest (>5 per 1000) in high-income North America, Oceania, and Eastern Europe. In women, HF prevalence in 2010 was highest (4.53 per 1000) in Oceania, followed by high-income North America and North Africa/Middle East. For both men and women, HF prevalence was lowest in west sub-Saharan Africa (0.74/1000 in men and 0.57/1000 in women).[30] HF made the largest contribution to age-standardized years lived with disability among men in high-income North America, Oceania, Eastern and Western Europe, southern Latin America, and Central Asia.[30] HF risk factors vary substantially across world regions, with hypertension being highly associated with HF in all regions but with cardiomyopathy being most common in Latin America, the Caribbean, and sub-Saharan Africa, and a minimal association with ischemic HD in sub-Saharan Africa.[31]

Risk Factors

- NHANES found that the traditional risk factors for HF and their PARs were as follows[32]:
  - —CHD: RR, 8.1; overall PAR, 62% (68% in men and 56% in women)
  - —Cigarette smoking: RR, 1.6; PAR, 17%
  - —Hypertension: RR, 1.4; PAR, 10%
  - —Obesity: RR, 1.3; PAR, 8%
  - —DM: RR, 1.9; PAR, 3%
  - —Dietary sodium intake: RR, 1.4; PAR, not available[33]
  - —Valvular HD: RR, 1.5; PAR, 2%[34]
- Among 20 900 male physicians in the Physicians Health Study, the lifetime risk of HF was higher in men with hypertension; healthy lifestyle factors (normal weight, not smoking, regular PA, moderate alcohol intake, consumption of breakfast cereals, and consumption of fruits and vegetables) were related to lower risk of HF.[35]
- In older adults, both current and past cigarette smoking increase HF risk. In current smokers, this risk is high irrespective of pack-years of exposure, whereas in past smokers, there was a dose-effect association.[36]
- Racial differences in risk factors for HF were observed in a US cohort of 2934 adults aged 70 to 79 years followed up for 7 years. Among blacks, a greater proportion of HF risk (68% versus 49% among whites) was attributable to modifiable risk factors, including elevated SBP, elevated fasting glucose level, CHD, LV hypertrophy and smoking. LV hypertrophy was 3-fold more prevalent in blacks than in whites.[37]
- Among 2934 participants in the ABC study, the incidence of HF was 13.6 per 1000 person-years. Men and black participants were more likely to develop HF. CHD (PAR 23.9% for white participants, 29.5% for black participants) and uncontrolled BP (PAR 21.3% for white participants, 30.1% for black participants) had the highest PARs in both races. There was a higher proportion of HF attributable to modifiable risk factors in black than in white participants (67.8% versus 48.9%).[37]
- Hispanics carry a predominance of HF risk factors and healthcare disparities, which suggests a high HF risk in this population.[38]
- Nontraditional HF risk factors are as follows:
  - —In the NHLBI-sponsored FHS, BNP, urinary albumin-to-creatinine ratio, elevated serum γ-glutamyl transferase, and higher levels of hematocrit were identified as risk factors for incident HF.[39–41]
  - —In the Framingham Offspring Study, among 2739 participants, increased circulating concentrations of resistin were associated with incident HF independent of prevalent coronary disease, obesity, insulin resistance, and inflammation.[42]
  - —Adiponectin was also associated with risk of HF (J-shaped relationship).[43]

—Inflammatory markers (interleukin-6 and tumor necrosis factor-α), serum albumin levels, and cigarette smoking exposure were also associated with HF risk.[36,44,45]

- In the CHS, baseline cardiac high-sensitivity troponin and changes in high-sensitivity troponin levels were significantly associated with incident HF.[46] Circulating individual and total omega-3 fatty acid concentrations were associated with lower incidence of HF.[47]

—In the ARIC study, white blood cell count, CRP, albuminuria, HbA_{1c} among individuals without DM, cardiac troponin, ventricular premature complexes, and socioeconomic position over the life course were all identified as risk factors for HF.[48–53]

—In MESA, plasma N-terminal pro-BNP provided incremental prognostic information beyond the traditional risk factors and the magnetic resonance imaging–determined LV mass index for incident symptomatic HF.[54]

LV Function

- Data from Olmsted County, MN, indicate the following:

—Among all individuals (asymptomatic or with validated clinical HF), the prevalence of LV diastolic dysfunction was 21% for mild diastolic dysfunction and 7% for moderate or severe diastolic dysfunction. The prevalence of systolic dysfunction was 6%. The presence of any LV dysfunction (systolic or diastolic) was associated with an increased risk of overt HF, and asymptomatic diastolic dysfunction was predictive of all-cause death.[55,56] After 4 years of follow-up, the prevalence of diastolic dysfunction increased to 39.2%. Diastolic dysfunction was associated with development of clinical HF during 6 years of subsequent follow-up after adjustment for age, hypertension, DM, and CAD (HR, 1.81; 95% CI, 1.01–3.48).[57]

—Among individuals with symptomatic HF, 55% had HF with preserved EF. The prevalence of LV diastolic dysfunction was 6% for mild and 75% for moderate or severe diastolic dysfunction. HF with preserved EF is associated with a high mortality rate, comparable to that of HF with reduced EF.[58] Over a 15-year follow-up period, survival trends improved among individuals with HF with reduced EF but not among those with HF with preserved EF.[59]

—The prevalence of HF with preserved EF has increased over a 15-year period, whereas the rate of death attributable to this disorder has remained unchanged.[59] As a group, patients with HF with preserved EF are older, are more likely to be female, and have greater hypertension, obesity, and anemia than those with HF with reduced EF.[60]

- In the NHLBI-sponsored FHS, among asymptomatic individuals, the prevalence of systolic dysfunction was 5%; the prevalence of LV diastolic dysfunction was 36%. LV systolic dysfunction and LV diastolic dysfunction were associated with increased risk of incident HF. Major organ system dysfunction (higher serum creatinine, lower ratios of FEV_1 [forced expiratory volume in 1 second] to FVC [forced vital capacity], and lower hemoglobin concentrations) were also independently associated with increased risk of new-onset HF.[55]
- In MESA, the overall prevalence of asymptomatic LV systolic dysfunction was higher in African Americans than in whites, Chinese, and Hispanics. After 9 years of follow-up, asymptomatic LV dysfunction was associated with incident clinical HF (HR, 8.69; 95% CI, 4.89–15.4) after adjustment for cardiac risk factors.[56]

Hospital Discharges/Ambulatory Care Visits

(See Table 20-1 and Chart 20-4.)

- Hospital discharges for HF were essentially unchanged from 2000 to 2010, with first-listed discharges of 1 008 000 and 1 023 000, respectively (NHDS, NHLBI tabulation).[61]
- In 2012, there were 1 774 000 physician office visits with a primary diagnosis of HF (NAMCS, NHLBI tabulation). In 2011, there were 553 000 ED visits and 257 000 outpatient department visits for HF (NHAMCS, NHLBI tabulation).
- Among 1077 patients with HF in Olmsted County, MN, hospitalizations were common after HF diagnosis, with 83% patients hospitalized at least once and 43% hospitalized at least 4 times. More than one half of all hospitalizations were related to noncardiovascular causes.[62]
- Among Medicare beneficiaries, the overall HF hospitalization rate declined substantially from 1998 to 2008 but at a lower rate for black men.[25] Changes were uneven across states.
- Rates of cardiovascular death or HF hospitalization are greatest in those who have been previously hospitalized for HF.
- The ADHERE registry analysis documented that in-hospital mortality and length of stay for Hispanics were intermediate between those for non-Hispanic whites and African Americans.[63]
- On the basis of data from the community surveillance component of the ARIC study of the NHLBI[64]:

—The average incidence of hospitalized HF for those aged ≥55 years was 11.6 per 1000 people per year; recurrent hospitalized HF was 6.6 per 1000 people per year.

—Age-adjusted annual hospitalized HF incidence was highest for black men (15.7 per 1000), followed by black women (13.3 per 1000), white men (12.3 per 1000), and white women (9.9 per 1000).

—Of incident hospitalized HF events, 53% had HF with reduced EF and 47% had preserved EF. Black men had the highest proportion of hospitalized HF with reduced EF (70%); white women had the highest proportion of hospitalized HF with preserved EF (59%).

—Age-adjusted 28-day and 1-year case fatality after hospitalized HF was 10.4% and 29.5%, respectively, and did not differ by race or sex.

- Data from Olmsted County, MN, indicate that among those with HF, hospitalizations were particularly common among men and did not differ by HF with reduced EF versus preserved EF. Sixty-three percent of hospitalizations were for noncardiovascular causes. Among those with HF, hospitalization rates for cardiovascular causes did not change over time, whereas those for noncardiovascular causes increased (from 2000 to 2010).[18]

Cost

- In 2012, total cost for HF was estimated to be $30.7 billion. Of this total, 68% was attributable to direct medical costs.[11]
- Projections show that by 2030, the total cost of HF will increase almost 127% to $69.7 billion from 2012. This equals ≈$244 for every US adult.[11]

Table 20-1. Heart Failure

Population Group	Prevalence, 2012, Age ≥20 y	Incidence (New Cases), 2012, Age ≥55 y	Mortality, 2013, All Ages*	Hospital Discharges, 2010, All Ages	Cost, 2012†
Both sexes	5 700 000 (2.2%)	915 000	65 120	1 023 000	$30.7 billion
Males	2 700 000 (2.3%)	440 000	28 513 (43.8%)‡	501 000	…
Females	3 000 000 (2.2%)	475 000	36 607 (56.2%)‡	522 000	…
NH white males	2.2%	385 000§	23 847	…	…
NH white females	2.2%	405 000§	30 940	…	…
NH black males	2.8%	55 000§	2933	…	…
NH black females	3.2%	70 000§	3585	…	…
Hispanic males	2.1%	…	1144	…	…
Hispanic females	2.1%	…	1400	…	…
NH Asian or Pacific Islander	…	…	954 ‖	…	…
NH American Indian or Alaska Native	…	…	230	…	…

Heart failure includes people who answered "yes" to the question of ever having congestive heart failure.

Ellipses (…) indicate data not available; and NH, non-Hispanic.

*Mortality data for Hispanic, American Indian or Alaska Native, and Asian and Pacific Islander people should be interpreted with caution because of inconsistencies in reporting Hispanic origin or race on the death certificate compared with censuses, surveys, and birth certificates. Studies have shown underreporting on death certificates of American Indian or Alaska Native, Asian and Pacific Islander, and Hispanic decedents, as well as undercounts of these groups in censuses.

†Cost data are from Heidenreich et al.[11]

‡These percentages represent the portion of total mortality attributable to heart failure that is for males vs females.

§Estimates for whites include other nonblack races.

‖Includes Chinese, Filipino, Hawaiian, Japanese, and Other Asian or Pacific Islander.

Sources: Prevalence: National Health and Nutrition Examination Survey 2009 to 2012 (National Center for Health Statistics) and National Heart, Lung, and Blood Institute. Percentages are age adjusted for Americans ≥20 years of age. Age-specific percentages are extrapolated to the 2012 US population estimates. These data are based on self-reports. Incidence: Atherosclerosis Risk in Communities Study Community Surveillance, 2005 to 2012 from the National Heart, Lung, and Blood Institute. Mortality: Centers for Disease Control and Prevention/National Center for Health Statistics, 2013 Mortality Multiple Cause-of-Death–United States.

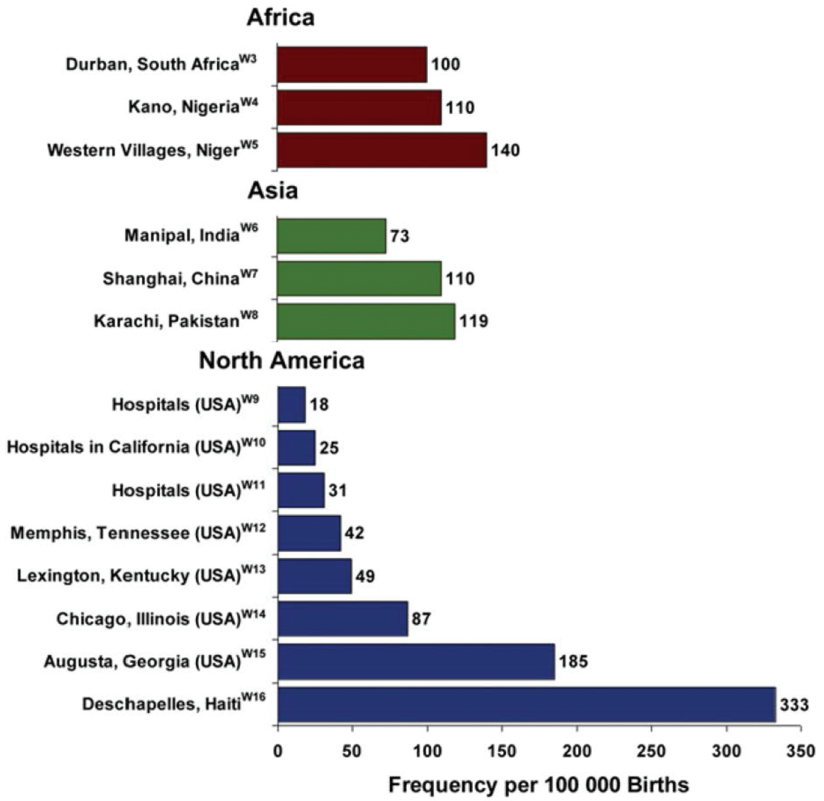

Chart 20-1. Incidence of peripartum cardiomyopathy. Reproduced from Blauwet et al,[65] copyright 2011, with permission from BMJ Publishing Group Ltd.

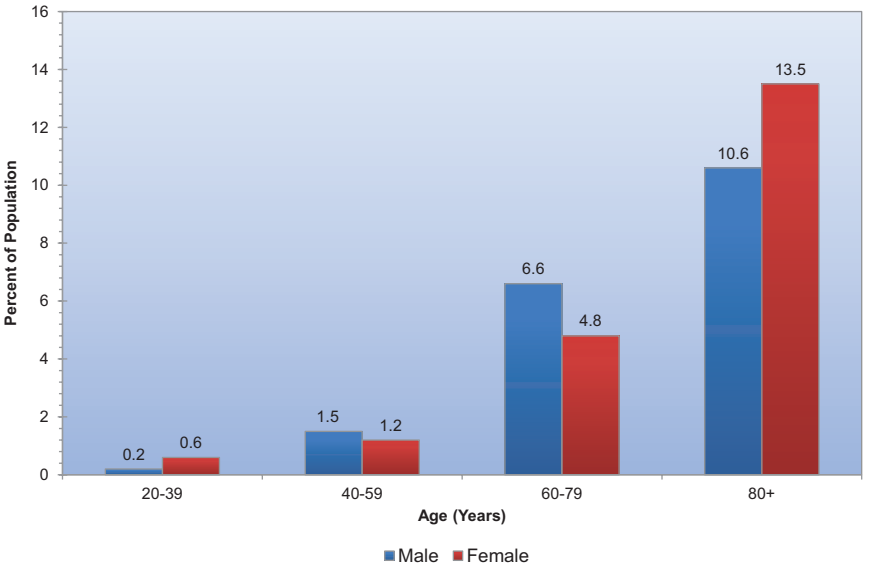

Chart 20-2. Prevalence of heart failure by sex and age (National Health and Nutrition Examination Survey: 2009–2012). Source: National Center for Health Statistics and National Heart, Lung, and Blood Institute.

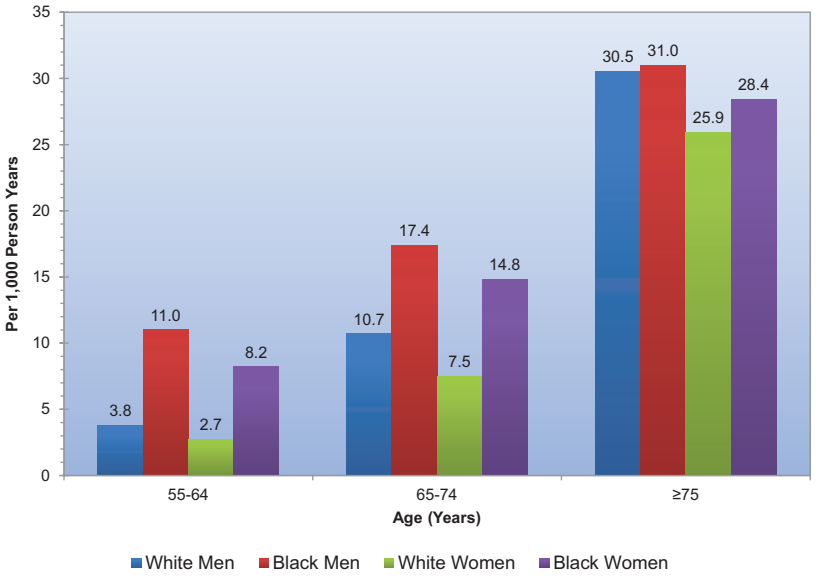

Chart 20-3. First acute decompensated heart failure annual event rates per 1000 from Atherosclerosis Risk in Communities community surveillance (2005–2012). Source: National Heart, Lung, and Blood Institute.

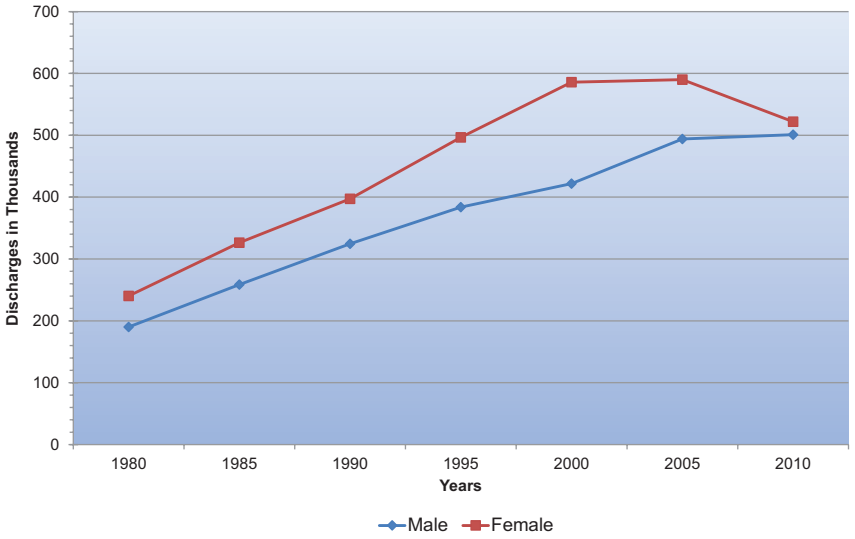

Chart 20-4. Hospital discharges for heart failure by sex (United States: 1980–2010). Hospital discharges include people discharged alive, dead, and status unknown. Source: National Hospital Discharge Survey/National Center for Health Statistics and National Heart, Lung, and Blood Institute.

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21. Valvular, Venous, and Aortic Diseases

See Tables 21-1 through 21-3 and Charts 21-1 through 21-3.

Mortality and any-mention mortality in this section are for 2013. "Mortality" is the number of deaths in 2013 for the given underlying cause based on *ICD-10*. Prevalence data are for 2006. Hospital discharge data are from the NHDS/NCHS; data include inpatients discharged alive, dead, or status unknown. Hospital discharge data for 2010 are based on *ICD-9* codes.

Valvular HD

(See Table 21-1.)

ICD-9 424; ICD-10 I34 to I38.

Mortality—24 608. Any-mention mortality—50 222. Hospital discharges—85 000.

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Abbreviations Used in Chapter 21

AAA	abdominal aortic aneurysm
AHA	American Heart Association
ARIC	Atherosclerosis Risk in Communities study
CARDIA	Coronary Artery Risk Development in Young Adults
CDC	Centers for Disease Control and Prevention
CHD	coronary heart disease
CHS	Cardiovascular Health Study
CI	confidence interval
CT	computed tomography
DM	diabetes mellitus
DVT	deep vein thrombosis
GBD	Global Burden of Diseases, Injuries, and Risk Factors Study
HD	heart disease
HR	hazard ratio
ICD	*International Classification of Diseases*
ICD-9	*International Classification of Diseases, 9th Revision*
ICD-10	*International Classification of Diseases, 10th Revision*
IE	infective endocarditis
IRAD	International Registry of Acute Aortic Dissection
LDL-C	low-density lipoprotein cholesterol
LV	left ventricular
NCHS	National Center for Health Statistics
NH	non-Hispanic
NHDS	National Hospital Discharge Survey
NHLBI	National Heart, Lung, and Blood Institute
OR	odds ratio
OVER	Open Versus Endovascular Repair
PE	pulmonary embolism
REGARDS	Reasons for Geographic and Racial Differences in Stroke
RR	relative risk
SD	standard deviation
UI	uncertainty interval
VTE	venous thromboembolism

- A large population-based epidemiological study with systematic use of echocardiography on 16 501 participants from Olmsted County, MN, showed an overall age-adjusted prevalence of clinically diagnosed (moderate or greater) valvular HD of 1.8%.[1]
- Prevalence of any valve disease increased with age[1]:

  —18 to 44 years: 0.3% (95% CI, 0.2%–0.3%)
  —45 to 54 years: 0.7% (95% CI, 0.6%–0.9%)
  —55 to 64 years: 1.6% (95% CI, 1.4%–1.9%)
  —65 to 74 years: 4.4% (95% CI, 3.9%–4.9%)
  —≥75 years: 11.7% (95% CI, 11.0%–12.5%)

- Pooled echocardiographic data from 11 911 participants from CARDIA (4351), ARIC (2435), and CHS (5125) demonstrated a similar increase in prevalence with age (Table 21-1).[1]

  —18 to 44 years: 0.7% (95% CI, 0.5%–1.0%)
  —45 to 54 years: 0.4% (95% CI, 0.1%–1.3%)
  —55 to 64 years: 1.9% (95% CI, 1.2%–2.8%)
  —65 to 74 years: 8.5% (95% CI, 7.6%–9.4%)
  —≥75 years: 13.3% (95% CI, 11.7%–15.0%)

- Adjusted to the entire US population, these data suggest that the prevalence of any valve disease is 2.5% (95% CI, 2.2%–2.7%), with no difference between men (2.4% [95% CI, 2.1%–2.8%]) and women (2.5% [95% CI, 2.1%–2.9%]). Within this sample, 0.4% had aortic stenosis, 0.5% had aortic regurgitation, 0.1% had mitral stenosis, and 1.7% had mitral regurgitation.[1]

Aortic Valve Disorders

ICD-9 424.1; ICD-10 I35.

Mortality—16 908. Any-mention mortality—33 931. Hospital discharges—55 000.

- The prevalence of moderate or severe aortic stenosis in patients ≥75 years old is 2.8% (95% CI, 2.1%–3.7%), and the prevalence of moderate or severe aortic regurgitation in patients ≥75 years is 2.0% (95% CI, 1.4%–2.7%).[1]
- Nationally representative data from Sweden demonstrate a lower age-adjusted incidence of aortic stenosis, from 15.0 to 11.4 per 100 000 men and from 9.8 to 7.1 per 100 000 women, between the years 1989 to 1991 and 2007 to 2009.[2]
- Multiple single-nucleotide polymorphisms that encode for LDL-C cholesterol have been combined to form a genetic risk score that has been associated with prevalent aortic valve calcification (OR, 1.38; 95% CI, 1.09–1.74 per genetic risk score increment) and incident aortic valve stenosis (HR, 2.78; 95% CI, 1.22–6.37 per genetic risk score increment) by use of a mendelian randomization design.[3]
- Approximately 50% of patients with severe aortic stenosis are referred for cardiothoracic surgery, and ≈40% undergo aortic valve replacement according to data from 10 US centers of various sizes and geographic distribution. Reasons for not undergoing aortic valve replacement included high perioperative risk, age, lack of symptoms, and patient/family refusal.[4]
- In a cohort of 416 community-based participants from Olmsted County, MN, with bicuspid aortic valves followed up for a mean (SD) of 16 (7) years, the incidence of aortic dissection in individuals ≥50 years of age at baseline was

17.4 (95% CI, 2.9–53.6) cases per 10 000 patient years. For patients aged ≥50 years with a bicuspid valve and a baseline aortic aneurysm, the incidence of aortic dissection was 44.9 (95% CI, 7.5–138.5) cases per 10 000 patient-years. In the remaining participants without baseline aortic aneurysm, the incidence of aneurysm was 84.9 (95% CI, 63.3–110.9) cases per 10 000 patient-years, for an age-adjusted RR of 86.2 (95% CI, 65.1–114) compared with the general population.[5]

Mitral Valve Disorders

ICD-9 424.0; ICD-10 I34.

Mortality—2275. Any-mention mortality—5169. Hospital discharges—22 000.

Prevalence

(See Table 21-1.)

- In pooled data from CARDIA, ARIC, and CHS, mitral valve disease was the most common valvular lesion. At least moderate mitral regurgitation occurred at a frequency of 1.7% as adjusted to the US adult population of 2000, increasing from 0.5% in participants aged 18 to 44 years to 9.3% in participants aged ≥75 years.[1]
- A systematic review by de Marchena and colleagues[6] found that in the US population, the prevalence of mitral regurgitation according to Carpentier's functional classification system was as follows:

  —Type I (congenital mitral regurgitation and endocarditis): <20 per 1 million
  —Type II (myxomatous mitral regurgitation): 15 000 per 1 million
  —Type IIIa (rheumatic HD, systemic lupus erythematosus, antiphospholipid syndrome): 10 520 per 1 million
  —Type IIIb (ischemic mitral regurgitation, LV dysfunction, dilated cardiomyopathy): 23 250 per 1 million

Pulmonary Valve Disorders

ICD-9 424.3; ICD-10 I37.

Mortality—14. Any-mention mortality—42.

Tricuspid Valve Disorders

ICD-9 424.2; ICD-10 I36.

Mortality—13. Any-mention mortality—88.

Rheumatic Fever/Rheumatic HD

(See Table 21-2 and Chart 21-1.)

ICD-9 390 to 398; ICD-10 I00 to I09.

Mortality—3260. Any-mention mortality—6087. Hospital discharges—20 000.

- Rheumatic HD is uncommon in high-income countries such as the United States but remains endemic in some low- and middle-income countries. Data from the 2013 GBD study suggest that 275 100 (95% UIs 222 600–353 900) individuals died of rheumatic HD in 2013, which is a 27% decline from the number of global deaths estimated in 1990. The GBD also estimates an age-adjusted mortality rate of 4.4 deaths per 100 000 (95% UI, 3.5–5.6) in 2013 attributable to rheumatic HD, which is a 55% lower rate than in 1990.[7]
- The 2013 overall age-adjusted death rate for rheumatic fever/rheumatic HD in the United States was 0.9 per 100 000. Death rates varied across race/ethnic groups but were generally low: non-Hispanic white, 1.0 per 100 000; non-Hispanic black or African American, 0.7 per 100 000; non-Hispanic Asian or Pacific Islander, 0.8 per 100 000; non-Hispanic American Indian or Alaska Native, 1.1 per 100 000; and Hispanic or Latino-origin individuals, 0.5 per 100 000.[8]
- In 1950, ≈15 000 Americans (adjusted for changes in *ICD* codes) died of rheumatic fever/rheumatic HD compared with ≈3100 annually in the present era (NCHS/NHLBI).

Bacterial Endocarditis

(See Table 21-3)

ICD-9 421.0; ICD-10 I33.0.

Mortality—1216. Any-mention mortality—2546. Hospital discharges—34 000, primary plus secondary diagnoses.

- According to the 2013 GBD study, the age-standardized death rate attributable to endocarditis in 2013 was 1.0 per 100 000 (95% UI, 0.8–1.3), which represents a 13% median decrease since 1990. However, because of population growth and aging, the number of deaths attributable to endocarditis increased from 45 100 (95% UI, 35 600–58 600) in 1990 to 65 000 (95% UI, 48 600–79 400) in 2013.[7]
- Although the absolute risk for acquiring IE from a dental procedure is impossible to measure precisely, the best available estimates are as follows: If dental treatment causes 1% of all cases of viridans group streptococcal IE annually in the United States, the overall risk in the general population is estimated to be as low as 1 case of IE per 14 million dental procedures. The estimated absolute risk rates for acquiring IE from a dental procedure in patients with underlying cardiac conditions are as follows[9]:

  —Mitral valve prolapse: 1 per 1.1 million procedures
  —CHD: 1 per 475 000
  —Rheumatic HD: 1 per 142 000
  —Presence of a prosthetic cardiac valve: 1 per 114 000
  —Previous IE: 1 per 95 000 dental procedures

- Data collected between 2004 and 2010 from the Pediatric Health Information System database from 37 centers that included 1033 cases of IE demonstrate a mortality rate of 6.7% (n=45) and 3.5% (n=13) among children (0 to 19 years) with and without congenital heart disease, respectively.[10]
- Data from the Nationwide Inpatient Sample (2000–2011) suggest no change in temporal trends in the incidence of IE before and after publication of the 2007 AHA guideline for antibiotic prophylaxis before dental procedures.[11] In addition, cessation of antibiotic prophylaxis for IE before dental procedures has not led to a change in pediatric cases of endocarditis. Using 2003 to 2010 data from 37 centers in the Pediatric Health Information Systems Database, Pasquali and colleagues[12] did not demonstrate a significant difference in the number of IE hospitalizations after the guidelines were implemented in 2007 (1.6% difference after versus before guideline implementation; 95% CI, −6.4% to 10.3%; P=0.7).

- A systematic review that included 160 studies and 27 083 patients from 1960 to 2011 demonstrated that in hospital-based studies (142 studies; 23 606 patients), staphylococcal endocarditis has increased over time (coagulase-negative *Staphylococcus* 2% to 10%, $P<0.001$), with recent increases in *Staphylococcus aureus* (21% to 30%, $P<0.05$) and enterococcal IE (6.8% to 10.5%, $P<0.001$) over the past decade and a corresponding decrease in streptococcal endocarditis (32% to 17%) over the same time period.[13]
- Cardiac device IE appears to be present in 6.4% (95% CI, 5.5%–7.4%) of patients with definite IE, according to data from the International Collaboration on Endocarditis–Prospective Cohort Study (2000–2006). Nearly half (45.8%; 95% CI, 38.3%–53.4%) of such cases are associated with healthcare-associated infection. In-hospital and 1-year mortality rates for these patients were 14.7% (26/177; 95% CI, 9.8%–20.8%) and 23.2% (41/177; 95% CI, 17.2%–30.1%), respectively.[14]

Endocarditis, Valve Unspecified

ICD-9 424.9; ICD-10 I38.

Mortality—5398. Any-mention mortality—11 205.

VTE Epidemiology (Including DVT and PE)

Pulmonary Embolism

ICD-9 415.1; ICD-10 I26.

Mortality—7902. Any-mention mortality—31 129. Hospital discharges—186 000.

Deep Vein Thrombosis

ICD-9 451.1; ICD-10 I80.2.

Mortality—2551. Any-mention mortality—13 511.

Incidence

- Information on incidence is limited in the United States, but the CDC estimates an annual incidence of 300 000 to 600 000 VTE events; however, these data are derived from estimates that are ≥10 years old.[15–17]
- In the contemporary REGARDS cohort of 30 239 black and white adults ≥45 years old recruited from 2003 to 2007 and followed up for ≈2 years, age-standardized incidence rates of VTE were 1.4 to 2.2 per 1000 person-years.[18]
- VTE incidence appears to be similar or higher among African Americans and lower among Asian Americans and Native Americans than among whites.[19]
- Incidence rates increase exponentially with age for both men and women and for both DVT and PE.[15,20,21]
- Incidence rates are higher in women during childbearing years, whereas incidence rates after age 45 years are higher in men.
- PE accounts for an increasing proportion of VTE with increasing age in both sexes.

Survival

- Data from 1999 show that 30-day VTE survival is 72.0% (DVT alone, 94.5% compared with PE with or without DVT, 55.6%).[22]
- Data from a Worcester, MA, surveillance study from 1999 to 2009 suggested a decline in 3-year VTE-related mortality (from 41% to 26%). Because most PE deaths are sudden and often attributed to other diseases (eg, cancer, other chronic lung disease, or HD), secular trends in fatal PE are unclear as a result of low autopsy rates.

Recurrence

- VTE is a chronic disease with episodic recurrence; in the absence of long-term anticoagulation, ≈30% of patients develop recurrence within the next 10 years.[19]
- Data from a Worcester, MA, surveillance study from 1999 to 2009 suggested a declining rate of recurrent VTE (from 17% to 9%), perhaps attributable to increased use of long-term anticoagulation.[23]
- Independent predictors of early (within 180 days) recurrence include active cancer and inadequate anticoagulation. Two-week case fatality for recurrent DVT alone and recurrent PE with or without DVT is 2% and 11%, respectively.[24]
- Data from a Worcester, MA, surveillance study from 1999 to 2009 suggested a declining 3-year rate of major bleeding after a VTE (from 12% to 6%).[23]

Complications

- The 20-year cumulative incidence of postthrombotic syndrome/venous stasis syndrome and venous ulcer after proximal DVT is 40% and 3.7%, respectively.[25]
- The incidence of chronic thromboembolic pulmonary hypertension is 6.5 per million person-years; ≈1400 incident cases occur annually among US whites.[26]

Risk Factors

- Independent VTE risk factors include increasing patient age, surgery, trauma/fracture, hospital or nursing home confinement, active cancer, central vein catheters or transvenous pacemaker, prior superficial vein thrombosis, infection, varicose veins, inherited thrombophilia, kidney disease, and neurological disease with leg paresis, and among women, use of oral contraceptives, pregnancy/postpartum period, and hormone therapy.[27,28]
- Among patients hospitalized for acute medical illness, independent risk factors for VTE include prior VTE, thrombophilia, cancer, age >60 years, leg paralysis, immobilization ≥7 days, and admission to an intensive care unit or coronary care unit.[29]
- Pregnancy-associated VTE incidence is 200 per 100 000 woman-years; compared with nonpregnant women of childbearing age, the RR for VTE is increased 4-fold. VTE risk appears to be higher for pregnancies after in vitro fertilization than for natural pregnancies.[30]
- VTE risk during the postpartum period is ≈5-fold higher than during pregnancy.

Arteries, Diseases of

ICD-9 440 to 448; ICD-10 I70 to I78.

Penetrating Aortic Ulcers

- A single-center evaluation of 388 penetrating aortic ulcers found on CT angiography (2003–2009) demonstrated penetrating aortic ulcers in the aortic arch (6.8%), descending

thoracic aorta (61.2%), and abdominal aorta (29.7%). Nearly 2 of every 3 penetrating aortic ulcers (57.7%) did not have a saccular aneurysm or intramural hematoma, whereas ≈1 in 4 (27.8%) had associated saccular aneurysms, and ≈1 in 7 (14.4%) had an associated intramural hematoma. Rupture was present in ≈1 in 25 penetrating aortic ulcers (4.1%).[31]

Aortic Aneurysm

(See Charts 21-2 and 21-3.)

ICD-9 441; ICD-10 I71.

Mortality—9846. Any-mention mortality—16 147. Hospital discharges—64 000.

- According to the 2013 GBD study, the age-standardized death rate attributable to aortic aneurysm in 2013 was 2.6 per 100 000 (95% UI, 2.1–3.1), which represents a 15% median decrease since 1990. However, because of population growth and aging, the number of deaths attributable to AAAs increased from 99 600 (95% UI, 824 000–118 500) in 1990 to 151 500 (95% UI, 124 200–180 000) in 2013.[7]
- The prevalence of AAAs that are 2.9 to 4.9 cm in diameter ranges from 1.3% in men 45 to 54 years of age to 12.5% in men 75 to 84 years of age. For women, the prevalence ranges from 0% in the youngest to 5.2% in the oldest age groups.[32]
- A meta-analysis of 15 475 individuals from 18 studies on small AAAs (3.0–5.4 cm) demonstrated that mean aneurysm growth rate was 2.21 mm per year and was independent of age and sex. Growth rates were higher in smokers (by 0.35 mm/y) and lower in patients with DM (by 0.51 mm/y).[33]
- A 2014 systematic review of 17 community-based observational studies demonstrated a consistent, inverse association between DM and prevalent AAAs (OR, 0.80; 95% CI, 0.70–0.90).[34]
- On the basis of nationally representative data from the United Kingdom, giant cell arteritis has been demonstrated to be associated with a 2-fold higher risk (sub-HR, 1.92; 95% CI, 1.52–2.41) after adjustment for competing risks for developing an AAA. These data also demonstrate an inverse association between DM and AAA.[35]
- Rupture rates range from 0.71 to 11.03 per 1000 person-years, with higher rupture rates in smokers (pooled HR, 2.02; 95% CI, 1.33–3.06) and women (pooled HR, 3.76; 95% CI, 2.58–5.47).[33]
- A 2015 systematic review that included 4 randomized trials of ultrasound screening demonstrated lower AAA-associated mortality, emergency operations, and rupture but with higher AAA-associated elective repair rates.[36] The number needed to screen to prevent an AAA death or rupture was dependent on length of follow-up; however, there was no effect on overall mortality. Similar results were reported in a systematic review report prepared for the US Preventive Services Task Force.[37]
- Data from IRAD demonstrate that the rate of mesenteric malperfusion in 1809 patients with type A acute dissections is 3.7%, with a higher mortality rate than for patients without malperfusion (63.2% versus 23.8%, $P<0.001$).[38]
- Data from IRAD demonstrated that patients with acute type B aortic dissection have heterogeneous in-hospital outcomes. In-hospital mortality in patients with and without complications (such as mesenteric ischemia, renal failure, limb ischemia, or refractory pain) was 20.0% and 6.1%, respectively. In patients with complications, in-hospital mortality associated with surgical and endovascular repair was 28.6% and 10.1% ($P=0.006$), respectively.[39]

Thoracic Aortic Aneurysm Treatment

- A sample of 12 573 and 2732 Medicare patients who underwent open thoracic aortic aneurysm and endovascular repair demonstrated higher perioperative mortality for open repair in both intact (7.1% versus 6.1%, $P=0.07$) and ruptured (46% versus 28%, $P<0.01$) thoracic aortic aneurysms but higher 1-year (87% versus 82%, $P=0.001$) and 5-year (72% versus 62%, $P=0.001$) survival rates.[40]
- On the basis of data from the Nationwide Inpatient Sample (n=1400), weekend repair for thoracic aortic aneurysm rupture (n=322) was associated with higher mortality than weekday repair (n=1078; OR, 2.55; 95% CI, 1.77–3.68), likely because of delays in surgical intervention.[41]
- Perioperative mortality rates for open thoracic aortic aneurysms were higher for black Medicare patients than for white Medicare patients (18% versus 10%, $P<0.001$), but rates were similar for endovascular repair (8% versus 9%, $P=0.56$).[42]

AAA Treatment

- Results from 4 trials (n=3314 participants) evaluating the effect of open or endovascular repair of small AAAs (4.0–5.5 cm) did not demonstrate an advantage to earlier intervention compared with routine ultrasound surveillance.[43]
- Data from 23 838 patients with ruptured AAAs collected through the Nationwide Inpatient Sample (2005–2010) demonstrate in-hospital mortality of 53.2% (95% CI, 51.3%–54.9%), with 80.4% (95% CI, 79.0%–81.9%) undergoing intervention for repair. Of individuals who underwent repair, 20.9% (95% CI, 18.6%–23.2%) underwent endovascular repair, with a 26.8% (95% CI, 23.7%–30.0%) postintervention mortality, and 79.1% (95% CI, 76.8%–81.4%) underwent open repair with a 45.6% (95% CI, 43.6%–47.5%) postintervention mortality.[44]
- Data from the Nationwide Inpatient Sample suggest that the use of endovascular repair of AAA has risen substantially between 2000 and 2010 (5% versus 74% of all AAA repairs, respectively), whereas the overall number of AAAs (≈45 000 per year) has remained stable. In-hospital mortality and length of stay have declined during this period, but costs have risen.[45]
- Long-term results from the OVER trial that compared open AAA repair to endovascular repair demonstrated no survival difference between open and endovascular repair at a median follow-up of 9 years (HR, 0.97; 95% CI, 0.77–1.22) despite reductions in mortality from endovascular repair at 2 years (HR, 0.63; 95% CI, 0.40–0.98) and 3 years (HR, 0.72; 95% CI, 0.51–1.00).[46]
- After multivariable adjustment, Medicare patients who underwent open AAA repair had a higher risk of all-cause mortality (HR, 1.24; 95% CI, 1.05–1.47) and AAA-related mortality (HR, 4.37; 95% CI, 2.51–7.66) at 1 year than patients who underwent endovascular repair.[47]

Table 21-1. Pooled Prevalence of Valvular Heart Disease From CARDIA, ARIC, and CHS Cohorts

	Age, y						
	18–44	45–54	55–64	65–74	≥75	*P* Value for Trend	Frequency Adjusted to 2000 US Adult Population
Participants, n	4351	696	1240	3879	1745	…	209 128 094
Male	1959 (45)	258 (37)	415 (33)	1586 (41)	826 (47)	…	100 994 367 (48)
Mitral regurgitation (n=449)	23 (0.5)	1 (0.1)	12 (1.0)	250 (6.4)	163 (9.3)	<0.0001	1.7% (95% CI, 1.5%–1.9%)
Mitral stenosis (n=15)	0 (0)	1 (0.1)	3 (0.2)	7 (0.2)	4 (0.2)	0.006	0.1% (95% CI, 0.02%–0.2%)
Aortic regurgitation (n=90)	10 (0.2)	1 (0.1)	8 (0.7)	37 (1.0)	34 (2.0)	<0.0001	0.5% (95% CI, 0.3%–0.6%)
Aortic stenosis (n=102)	1 (0.02)	1 (0.1)	2 (0.2)	50 (1.3)	48 (2.8)	<0.0001	0.4% (95% CI, 0.3%–0.5%)
Any valve disease							
Overall (n=615)	31 (0.7)	3 (0.4)	23 (1.9)	328 (8.5)	230 (13.2)	<0.0001	2.5% (95% CI, 2.2%–2.7%)
Women (n=356)	19 (0.8)	1 (0.2)	13 (1.6)	208 (9.1)	115 (12.6)	<0.0001	2.4% (95% CI, 2.1%–2.8%)
Men (n=259)	12 (0.6)	2 (0.8)	10 (2.4)	120 (7.6)	115 (14.0)	<0.0001	2.5% (95% CI, 2.1%–2.9%)

Values are n (%) unless otherwise indicated. ARIC indicates Atherosclerosis Risk in Communities study; CARDIA, Coronary Artery Risk Development in Young Adults; CHS, Cardiovascular Health Study; CI, confidence interval; and ellipses (…), not applicable.

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Table 21-2. Rheumatic Fever/Rheumatic Heart Disease

Population Group	Mortality, 2013: All Ages*	Hospital Discharges, 2010: All Ages
Both sexes	3260	20 000
Males	1141 (35.0%)†	5000
Females	2119 (65.0%)†	15 000
NH white males	932	…
NH white females	1765	…
NH black males	98	…
NH black females	153	…
Hispanic males	52	
Hispanic females	110	
NH Asian or Pacific Islander	122‡	…
NH American Indian or Alaska Native	21	…

Ellipses (…) indicate data not available; and NH, non-Hispanic.

*Mortality for American Indian or Alaska Native and Asian and Pacific Islander people should be interpreted with caution because of inconsistencies in reporting race on the death certificate compared with censuses, surveys, and birth certificates. Studies have shown underreporting on death certificates of American Indian or Alaska Native, Asian and Pacific Islander, and Hispanic decedents, as well as undercounts of these groups in censuses.

†These percentages represent the portion of total mortality that is for males vs females.

‡Includes Chinese, Filipino, Hawaiian, Japanese, and Other Asian or Pacific Islander.

Sources: Mortality: Centers for Disease Control and Prevention/National Center for Health Statistics, 2013 Mortality Multiple Cause-of-Death–United States; data represent underlying cause of death only. Hospital discharges: National Hospital Discharge Survey, National Center for Health Statistics, and National Heart, Lung, and Blood Institute; data include those inpatients discharged alive, dead, or of unknown status.

Table 21-3. Incidence of IE and Valve Replacement From 2000 to 2011[11]

Year	Total IE Cases	IE Incidence per 100 000	Valve Replacement per 1000 IE Cases
2000	29 820	11	14
2001	31 526	11	16
2002	32 229	11	19
2003	35 190	12	18
2004	36 660	13	19
2005	37 508	13	23
2006	40 573	14	23
2007	38 207	12	30
2008	41 143	14	19
2009	43 502	14	27
2010	43 560	14	27
2011	47 134	15	26

IE indicates infective endocarditis.

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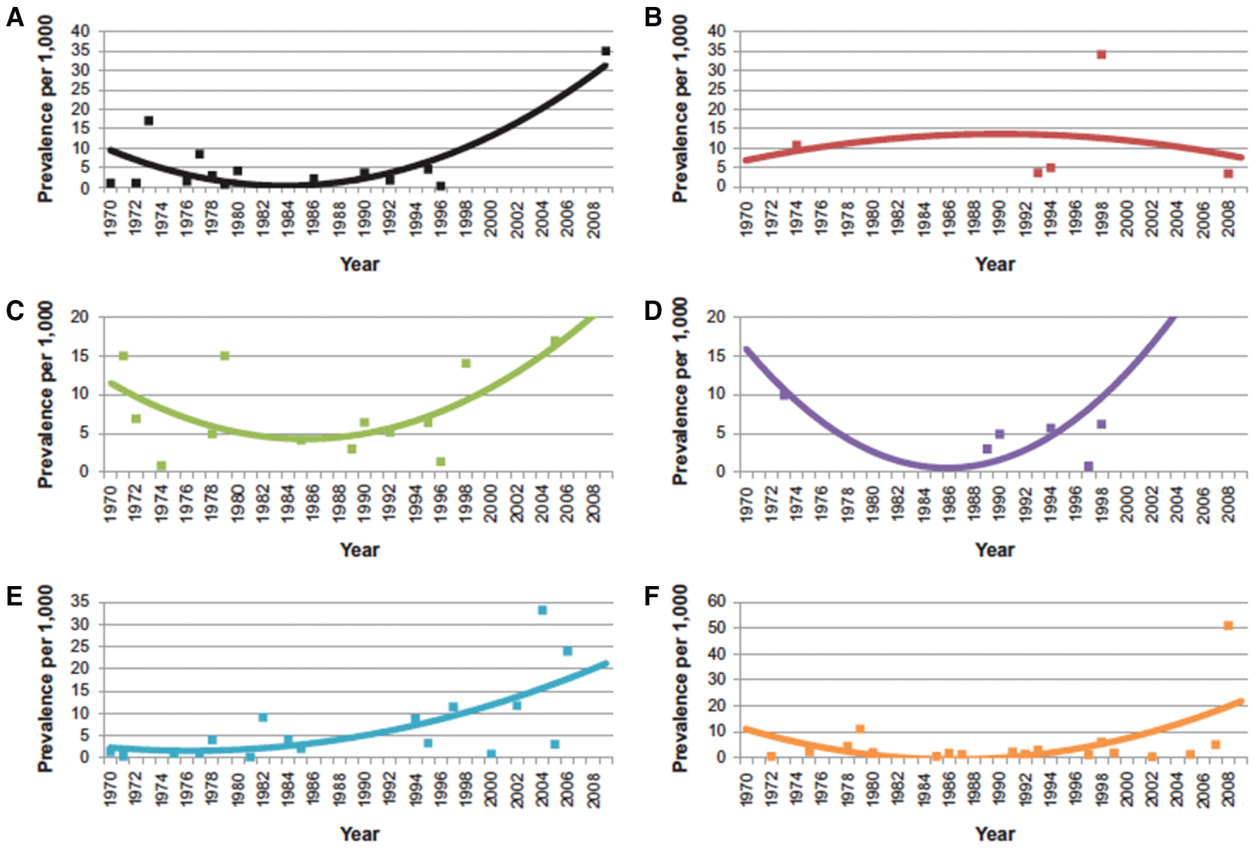

Chart 21-1. Rheumatic heart disease prevalence trends per 1000 people for each World Health Organization region: **A**, The Americas; **B**, Europe; **C**, Africa; **D**, Eastern Mediterranean; **E**, Western Pacific; and **F**, Southeast Asia. Reprinted from Seckeler and Hoke.[48] Copyright © 2011, Seckeler and Hoke (see http://creativecommons.org/licenses/by-nc/3.0/us/).

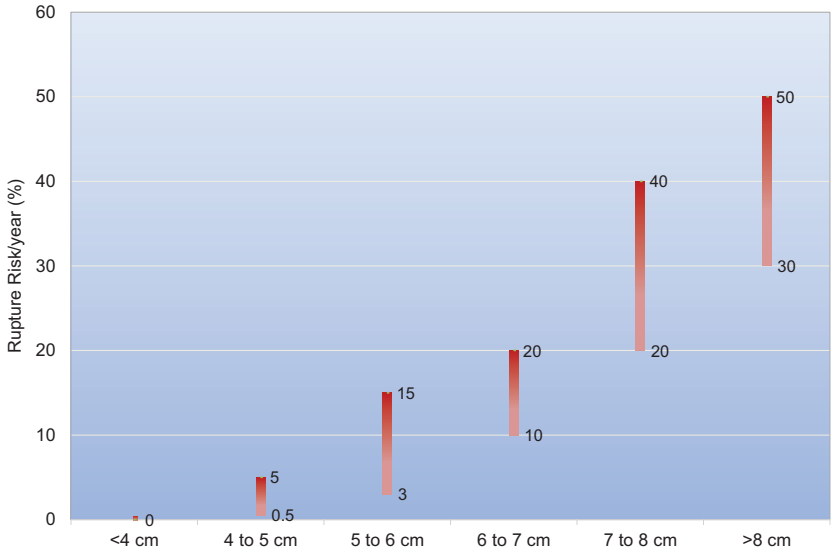

Chart 21-2. Association between the diameter and the minimum and maximum risk of abdominal aortic aneurysm (AAA) rupture per year. Data derived from Brewster et al.[49]

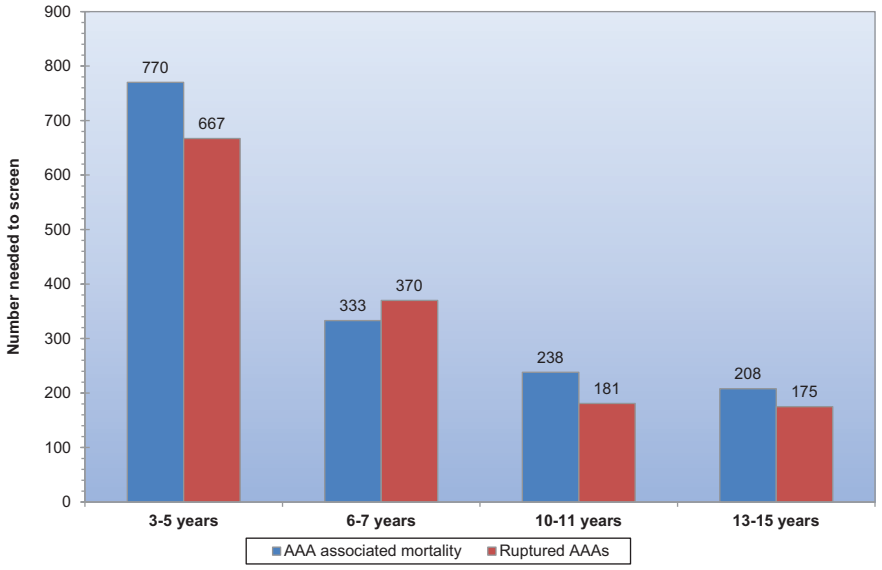

Chart 21-3. Numbers needed to screen to avoid an abdominal aortic aneurysm (AAA)–associated death and a ruptured abdominal aortic aneurysm. Data derived from Eckstein et al.[36]

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22. Peripheral Artery Disease

ICD-9: 440.20 to 440.24, 440.30 to 440.32, 440.4, 440.9, 443.9, 445.02; ICD-10: I70.2, I70.9, I73.9, I74.3, I74.4. See Table 22-1 and Charts 22-1 through 22-3.

Prevalence and Incidence

(See Table 22-1 and Charts 22-1 and 22-2.)

- PAD affects ≈8.5 million Americans aged ≥40 years and is associated with significant morbidity and mortality.[1]
- The age-standardized prevalence rate of PAD per 100 000 in 2010 was 185.6 (95% CI, 150.3–226.1), with minimal change (median percent change, 0.19% [95% CI, −24.1% to 31.6%]) since 1990. The age-standardized DALY rate of PAD per 100 000 in 2010 was 23.9 (95% CI, 15.7–38.3), with a median change of 24.9% since 1990.[2]
- The highest prevalence of PAD has been observed among elderly people, non-Hispanic blacks, and women. In a multivariable age-, sex-, and race/ethnicity-adjusted regression model, hypertension, DM, CKD, and smoking were associated with incident PAD ($P \leq 0.05$ for each).[3,4]
- A 2003 to 2008 sample of US national insurance claims of adults aged >40 years demonstrated that 263 270 eligible individuals had a PAD diagnosis, with an annual incidence and prevalence of 2.76% (95% CI, 2.75%–2.77%) and 12.29% (95% CI, 12.8%–12.31%), respectively.[5]
- In the general population, only ≈10% of people with PAD have the classic symptom of intermittent claudication. Approximately 40% do not complain of leg pain, whereas the remaining 50% have a variety of leg symptoms different from classic claudication.[6,7] Data from NHANES 1999 to 2002 suggest that up to two thirds of US adults with PAD who are ≥40 years old are asymptomatic, with one fourth having severe PAD (ABI <0.7).[8] In an older, disabled population of women, as many as two thirds of individuals with PAD had no exertional leg symptoms.[9]

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Abbreviations Used in Chapter 22

ABI	ankle brachial index
AHA	American Heart Association
Amer.	American
CHD	coronary heart disease
CI	confidence interval
CKD	chronic kidney disease
CVD	cardiovascular disease
DALY	disability-adjusted life-year
DM	diabetes mellitus
ED	emergency department
GBD	Global Burden of Diseases, Injuries, and Risk Factors Study
HBP	high blood pressure
HR	hazard ratio
ICD-9	*International Classification of Diseases, 9th Revision*
ICD-10	*International Classification of Diseases, 10th Revision*
MI	myocardial infarction
NCHS	National Center for Health Statistics
NH	non-Hispanic
NHAMCS	National Hospital Ambulatory Medical Care Survey
NHANES	National Health and Nutrition Examination Survey
NHDS	National Hospital Discharge Survey
NHLBI	National Heart, Lung, and Blood Institute
OR	odds ratio
PA	physical activity
PAD	peripheral artery disease
REACH	Reduction of Atherothrombosis for Continued Health
RR	relative risk
YLL	years of life lost

Mortality

(See Table 22-1.)

- In 2013, PAD any-mention mortality was 61 097 (29 506 males and 31 591 females). PAD was the underlying cause in 13 639 of those deaths in 2013.[10] Table 22-1 shows the numbers of these deaths that were coded for PAD as the underlying cause.
- The 2013 overall any-mention age-adjusted death rate for PAD was 17.0 per 100 000. Any-mention death rates in males were 20.4 for non-Hispanic whites, 25.1 for non-Hispanic blacks, 9.2 for non-Hispanic Asians or Pacific Islanders, 20.5 for non-Hispanic American Indians or Alaska Natives, and 16.6 for Hispanic males. In females, rates were 14.6 for non-Hispanic whites, 17.8 for non-Hispanic blacks, 7.0 for non-Hispanic Asians or Pacific Islanders, 14.5 for non-Hispanic American Indians or Alaska Natives, and 11.6 for Hispanic females.[10]
- The number of any-mention deaths attributable to PAD was higher in 2003 (87 430) than in 2013 (61 097; NCHS, AHA).[10]
- Data from the GBD project suggest that the age-standardized death rate attributable to PAD was 1.7 (95% CI, 1.0–2.9) per 100 000, with a 42% median increase since 1990. The YLL because of PAD was 21.2 (95% CI, 13.4–35.9), with a 29% median increase since 1990.[2]
- A 2008 meta-analysis of 24 955 men and 23 339 women demonstrated that the association of the ABI with mortality has a reverse J-shaped distribution in which participants with an ABI of 1.11 to 1.40 are at lowest risk for mortality. Low ABI (≤0.9) carried a 3-fold (RR, 3.33; 95% CI, 2.74–4.06) risk of all-cause death compared with men with normal ABI (1.11–1.40) and a similar risk in women (RR, 2.71; 95% CI, 2.03–3.62).[11]
- Among 508 patients (449 men) identified from 2 vascular laboratories in San Diego, CA, a decline in ABI of >0.15 within a 10-year period was associated with a subsequent increased risk of all-cause mortality (RR, 2.4; 95% CI, 1.2–4.8) and CVD mortality (RR, 2.8; 95% CI, 1.3–6.0) at 3 years' follow-up.[12]
- Among 440 patients with PAD, male sex and smoking were more associated with aortoiliac (proximal) disease than with infrailiac (distal) disease. In addition, aortoiliac disease was associated with an increased risk of mortality or cardiovascular events compared with infrailiac disease (adjusted HR, 3.28; 95% CI, 1.87–5.75).[13]

Risk Factors

- The risk factors for PAD are similar but not identical to those for CHD. DM and cigarette smoking are stronger risk factors for PAD than for CHD.[14] ORs for associations of DM and smoking with symptomatic PAD are ≈3.0 to 4.0. Most studies suggest that the prevalence of PAD is similar in men and women.[15] Metabolic syndrome in older people (driven most prominently by the HBP component) and elevated inflammation markers are also risk factors.[16]
- Pooled data from 11 studies in 6 countries found that PAD (defined by ABI <0.9) is a marker for systemic atherosclerotic disease and adverse clinical outcomes. The pooled age-, sex-, risk factor–, and CVD-adjusted RR for all-cause death was 1.60 (95% CI, 1.32–1.95), the RR for cardiovascular mortality was 1.96 (95% CI, 1.46–2.64), the RR for CHD was 1.45 (95% CI, 1.08–1.93), and the RR for stroke was 1.35 (95% CI, 1.10–1.65).[17]
- Cigarette smoking, DM, hypertension, and hypercholesterolemia, in that order, were important risk factors in high-income and low-income or middle-income countries.[18]
- A study of 3.3 million people in the United States 40 to 99 years of age showed that risk factor burden is associated with increased prevalence of PAD, and there is a graded association between the number of risk factor and the prevalence of PAD.[19]
- When the ABI was used to identify PAD, hypertension in pregnancy was found to be an independent risk factor for PAD decades after pregnancy after adjustment for demographics and traditional CVD risk factors.[20]
- A secondary analysis of a randomized feeding trial showed an HR, compared with a control group, of 0.34 (95% CI, 0.20–0.58) for incident PAD among participants randomized to the Mediterranean diet plus extra-virgin olive oil and 0.50 (95% CI, 0.30–0.81) for the Mediterranean diet plus nuts.[21]

Global Burden of PAD

(See Chart 22-3.)

- A systematic study of 34 studies reported that globally, 202 million people were living with PAD, and during the preceding decade, the number of individuals with PAD increased by ≈29% in the low-income or middle-income countries and by 13% in high-income countries.[18]

Awareness and Aftermath

- A cross-sectional, population-based telephone survey of >2500 adults ≥50 years of age, with oversampling of blacks and Hispanics, found that 26% expressed familiarity with PAD. Of these, half were not aware that DM and smoking increase the risk of PAD. One in 4 knew that PAD is associated with increased risk of MI and stroke, and only 14% were aware that PAD could lead to amputation. All knowledge domains were lower in individuals with lower income and education levels.[22]
- People with PAD have impaired function and quality of life. This is true even for people who do not report leg symptoms. Furthermore, patients with PAD, including those who are asymptomatic, experience a significant decline in lower-extremity functioning over time.[23–25]
- Among patients with established PAD, higher PA levels during daily life are associated with better overall survival rate, a lower risk of death because of CVD, and slower rates of functional decline.[26,27] In addition, better 6-minute walk performance and faster walking speed are associated with lower rates of all-cause mortality, cardiovascular mortality, and mobility loss.[28,29]
- From 2000 to 2008, the overall use of lower-extremity amputation decreased significantly during the study period, from 7258 to 5790 per 100 000 Medicare beneficiaries with PAD. There was significant geographic variation in the rate of lower-extremity amputation, from 8400 amputations per 100 000 patients with PAD in the East South Central region to 5500 amputations per 100 000 patients with PAD in the Mountain region. After adjustment for clustering at the US Census Bureau level, geographic variation in lower-extremity amputations remained. Lower-extremity amputation was performed more often in the East South Central region (adjusted OR, 1.152; 95% CI, 1.131–1.174; $P<0.001$) and West South Central region (adjusted OR, 1.115; 95% CI, 1.097–1.133; $P<0.001$) and less often in the Middle Atlantic region (OR, 0.833; 95% CI, 0.820–0.847; $P<0.001$) than in the South Atlantic region.[30]
- A 2003 to 2008 sample of US national insurance claims of adults >40 years of age demonstrated that 44 431 patients had a diagnosis of critical limb ischemia over the study period, with an annual incidence and prevalence of 0.47% (95% CI, 0.46%–0.47%) and 1.90% (95% CI, 1.89%–1.91%), respectively.[5]

Interventions

- Data from the REACH registry of 8273 PAD participants suggest that only 70% of PAD patients receive lipid-lowering therapy and only 82% receive antiplatelet therapy for secondary CVD prevention.[31]
- A 2011 systematic review evaluated lower-extremity aerobic exercise against usual care and demonstrated a range of benefits, including the following[32]:
  - —Increased claudication time by 71 seconds (79%) to 918 seconds (422%)
  - —Increased claudication distance by 15 m (5.6%) to 232 m (200%)
  - —Increased walking distance/time by 67% to 101% after 40 minutes of walking 2 to 3 times per week
- In a study that randomized patients with PAD to 3 groups (optimal medical care, supervised exercise training, and iliac artery stent placement), supervised exercise resulted in superior treadmill walking distance compared with stenting. Results in the exercise group and stent group were superior to optimal medical care alone.[33]
- In-hospital mortality was higher in women regardless of disease severity or procedure performed, even after adjustment for age and baseline comorbidities: 0.5% versus 0.2% after percutaneous transluminal angioplasty or stenting for intermittent claudication; 1.0% versus 0.7% after open surgery for intermittent claudication; 2.3% versus 1.6% after percutaneous transluminal angioplasty or

stenting for critical limb ischemia; and 2.7% versus 2.2% after open surgery for critical limb ischemia ($P<0.01$ for all comparisons).[34]

- A study of Medicare beneficiaries noted 39 339 underwent revascularization for PAD between 2006 and 2011, and the annual rate of peripheral vascular intervention increased slightly from 401.4 to 419.6 per 100 000 Medicare beneficiaries.[35]
- Among 186 338 older Medicare PAD patients undergoing major lower-extremity amputation, mortality was found to be 48.3% at 1 year.[36]

Hospital Discharges

(See Table 22-1.)

- Hospital discharges for PAD slightly increased from 2000 to 2010, with first-listed discharges of 135 000 and 146 000, respectively (unreliable estimate, NHDS, NHLBI tabulation).[37]
- In 2012, there were 1 126 000 physician office visits with a primary diagnosis of PAD.[37] In 2011, there were 19 000 ED visits and 291 000 outpatient department visits for PAD (NHAMCS, NHLBI tabulation).[37]

Table 22-1. Peripheral Artery Disease

Population Group	Prevalence, Age ≥40 y	Mortality, 2013, All Ages*	Hospital Discharges, 2010, All Ages
Both sexes	≥6.8 Million	13 639	146 000
Males	…	5846 (42.9%)†	84 000
Females	…	7793 (57.1%)†	62 000
NH white males	…	4775	…
NH white females	…	6447	…
NH black males	…	665	…
NH black females	…	847	…
Hispanic males	…	261	…
Hispanic females	…	331	…
NH Asian or Pacific Islander	…	223‡	…
NH American Indian/ Alaska Native	…	62	…

Ellipses (…) indicate data not available; and NH, non-Hispanic.

*Mortality for Hispanic, American Indian or Alaska Native, and Asian and Pacific Islander people should be interpreted with caution because of inconsistencies in reporting Hispanic origin or race on the death certificate compared with censuses, surveys, and birth certificates. Studies have shown underreporting on death certificates of American Indian or Alaska Native, Asian and Pacific Islander, and Hispanic decedents, as well as undercounts of these groups in censuses.

†These percentages represent the portion of total mortality attributable to heart failure that is for males vs females.

‡Includes Chinese, Filipino, Hawaiian, Japanese, and Other Asian or Pacific Islander.

Sources: Prevalence: Data derived from Allison et al.[1] Prevalence of peripheral artery disease is based on an ankle-brachial index <0.9 or a previous revascularization for peripheral artery disease. Mortality: Centers for Disease Control and Prevention/National Center for Health Statistics, 2013 Mortality Multiple Cause-of-Death–United States.

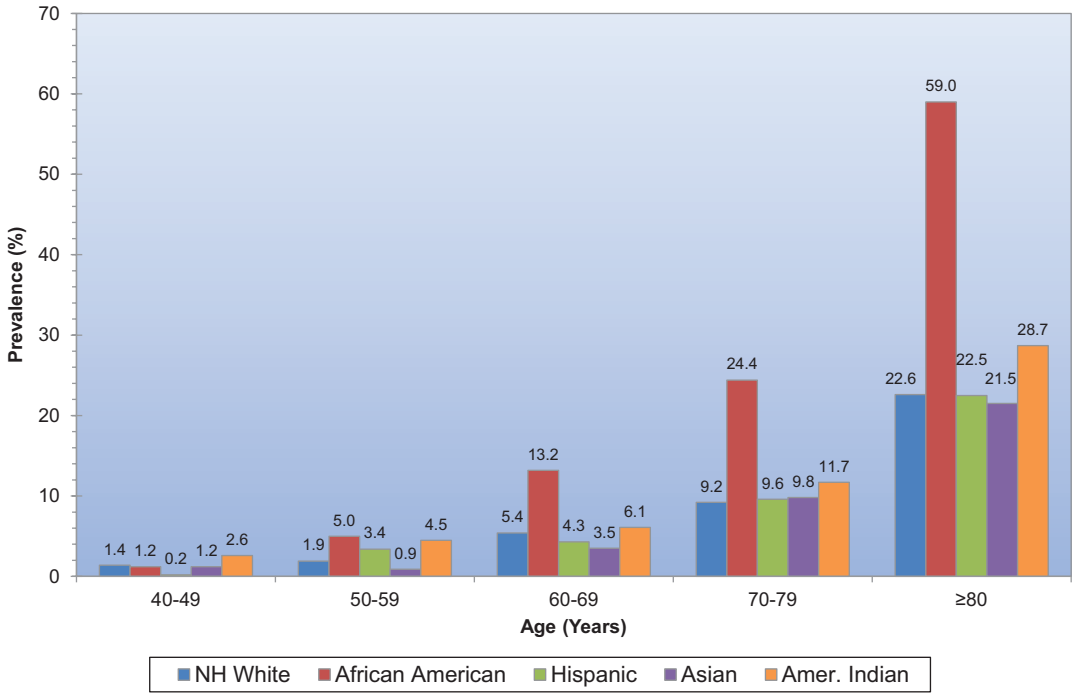

Chart 22-1. Estimates of prevalence of peripheral artery disease in males by age and ethnicity. Amer. indicates American; and NH, non-Hispanic. Data derived from Allison et al.[1]

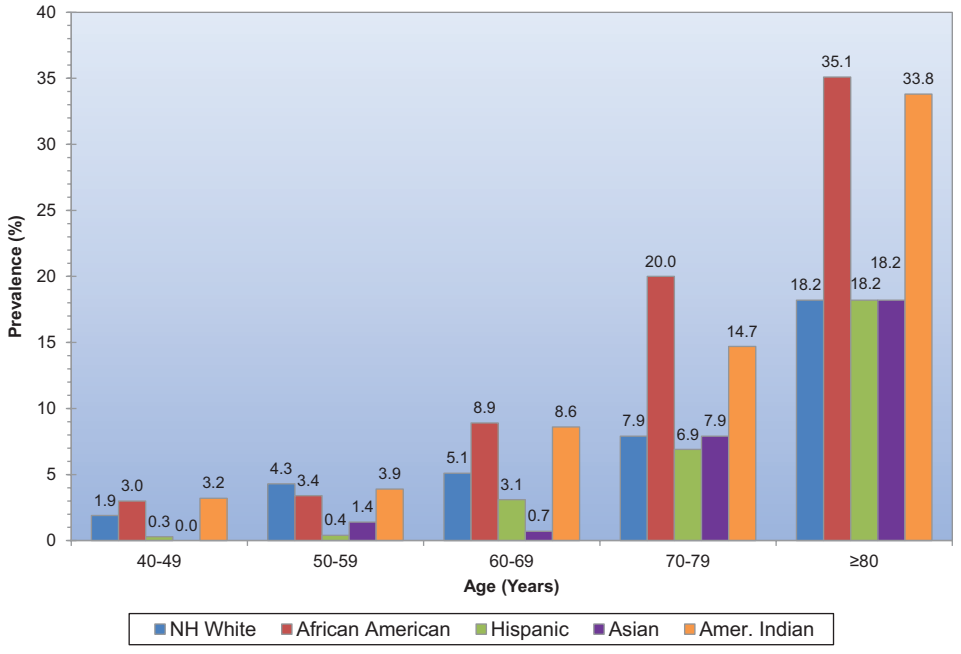

Chart 22-2. Estimates of prevalence of peripheral artery disease in females by age and ethnicity. Amer. indicates American; and NH, non-Hispanic. Data derived from Allison et al.[1]

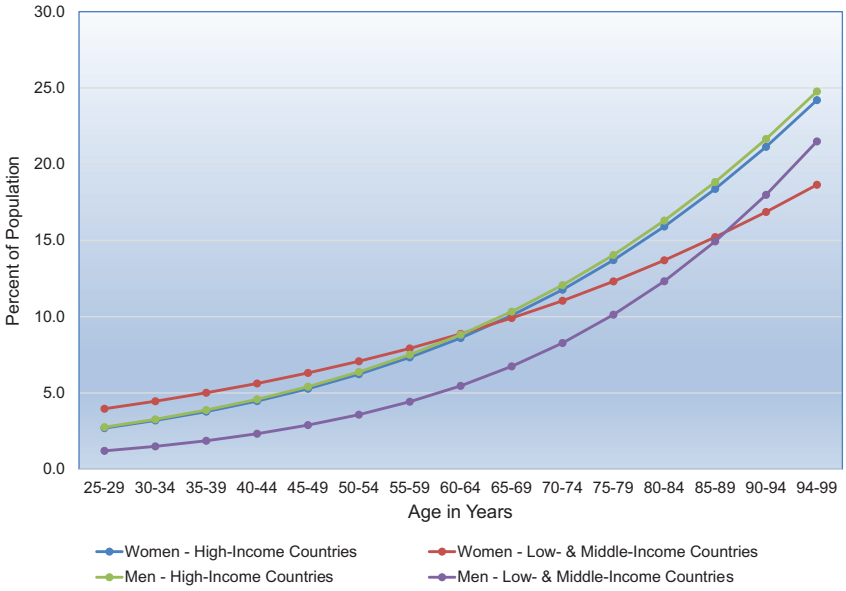

Chart 22-3. Age-specific prevalence estimates for peripheral artery disease by sex and country income level. Data derived from Fowkes et al.[18]

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23. Quality of Care

See Tables 23-1 through 23-13 and Chart 23-1.

The Institute of Medicine defines quality of care as "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge."[1] The Institute of Medicine has defined 6 specific domains for improving health care, including care that is safe, effective, patient centered, timely, efficient, and equitable.

In the following sections, data on quality of care will be presented based on the 6 domains of quality as defined by the Institute of Medicine. This is intended to highlight current care and to stimulate efforts to improve the quality of cardiovascular care nationally. Where possible, data are reported from recently published literature or standardized quality indicators from quality-improvement registries (ie, those consistent with the methods for quality performance measures endorsed by the ACC and the AHA).[2] Additional data related to quality of care, such as adherence to ACC/AHA clinical practice guidelines, are also included to provide a spectrum of quality-of-care data. The data selected are meant to provide examples of the current quality of care as reflected by the Institute of Medicine domains and are not meant to be comprehensive given the sheer number of publications yearly.

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Safety

The *safety* domain has been defined as avoiding injuries to patients from the care that is intended to help them. The

Abbreviations Used in Chapter 23

ACC	American College of Cardiology
ACEI	angiotensin-converting enzyme inhibitor
ACS	acute coronary syndrome
ACTION	Acute Coronary Treatment and Intervention Outcomes Network
AED	automated external defibrillator
AF	atrial fibrillation
AHA	American Heart Association
AMI	acute myocardial infarction
ARB	angiotensin receptor blocker
BMI	body mass index
BP	blood pressure
CABG	coronary artery bypass grafting
CAD	coronary artery disease
CART	Clinical Assessment, Reporting, and Tracking
CHD	coronary heart disease
CHF	congestive heart failure
CI	confidence interval
COURAGE	Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation
CPR	cardiopulmonary resuscitation
CRUSADE	Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines
CVD	cardiovascular disease
D2B	door-to-balloon
DES	drug-eluting stent
DM	diabetes mellitus
DNR	do not resuscitate
DVT	deep vein thrombosis
ECG	electrocardiogram
EF	ejection fraction
EMS	emergency medical services
$ETco_2$	end-tidal carbon dioxide
GBD	Global Burden of Diseases, Injuries, and Risk Factors Study
GWTG	Get With The Guidelines
HbA_{1c}	hemoglobin A_{1c} (glycosylated hemoglobin)
HD	heart disease
HF	heart failure
HMO	health maintenance organization
HR	hazard ratio
IHCA	in-hospital cardiac arrest
IQR	interquartile range
IV	intravenous
LDL-C	low-density lipoprotein cholesterol
LV	left ventricular
LVEF	left ventricular ejection fraction
LVSD	left ventricular systolic dysfunction
MD	medical doctor
MI	myocardial infarction
N/A	not available or not applicable
NCDR	National Cardiovascular Data Registry
NM	not measured
NSTEMI	non–ST-segment–elevation myocardial infarction
OHCA	out-of-hospital cardiac arrest
OR	odds ratio
PCI	percutaneous coronary intervention
PINNACLE	Practice Innovation and Clinical Excellence
PPO	preferred provider organization
ROC	Resuscitation Outcomes Consortium
RR	relative risk
SBP	systolic blood pressure
SD	standard deviation
STEMI	ST-segment–elevation myocardial infarction
STS	Society of Thoracic Surgeons
TIA	transient ischemic stroke
tPA	tissue-type plasminogen activator
TRIUMPH	Translational Research Investigating Underlying Disparities in Acute Myocardial Infarction Patients' Health Status
TVR	target-vessel revascularization
UFH	unfractionated heparin
VHA	Veterans Health Administration
VT/VF	ventricular tachycardia/ventricular fibrillation
YLL	years of life lost

following are several recent publications that have focused on safety issues related to cardiac care:

- In a small, single-center study conducted over a 2-month period in the cardiac care unit of a tertiary center, Rahim et al[3] demonstrated that iatrogenic adverse events were common (99 of 194 patients), of which bleeding (27%) was the most common preventable iatrogenic adverse event.
- Using the NCDR CathPCI Registry, Tsai et al[4] found that almost one fourth of dialysis patients undergoing PCI (n=22 778) received a contraindicated antithrombotic agent, specifically enoxaparin, eptifibatide, or both. Patients who received a contraindicated antithrombotic agent had an increased risk of in-hospital bleeding (OR, 1.63; 95% CI, 1.35–1.98) and a trend toward increased mortality (OR, 1.15; 95% CI, 0.97–1.36).
- Using data from the NCDR PINNACLE registry, Hira and colleagues[5] showed that among 27 533 patients receiving prasugrel, 13.9% (3824) did so for an inappropriate indication (history of TIA or strokes) and a further 4.4% (1210) did so for a nonrecommended indication (age >75 years without history of DM or MI). Both inappropriate and nonrecommended prasugrel use showed wide facility-level variation (median rate ratio of 2.89 [95% CI, 2.75–3.03] and 2.29 [95% CI, 2.05–2.51], respectively).
- In a random sample of medical and surgical long-term care adult patients in Massachusetts hospitals, López et al[6] assessed the association between disclosure of an adverse event and patients' perception of quality of care. Overall, only 40% of adverse events were disclosed. Higher quality ratings were associated with disclosure of an adverse event. Conversely, lower patient perception of quality of care was associated with events that were preventable and with events that caused discomfort.
- In an analysis from the ACC's NCDR PINNACLE registry, the authors showed that among 68 808 patients receiving aspirin therapy for primary prevention, roughly 11.6% (7972 of 68 808) were receiving inappropriate aspirin therapy (10-year risk of CVD <6%). There was significant practice-level variation in inappropriate use (range, 0%–71.8%; median, 10.1%; IQR, 6.4%) for practices with an adjusted median rate ratio of 1.63 (95% CI, 1.47–1.77).[7]
- Using Medicare Patient Safety Monitoring System data abstracted from medical records on 21 adverse events in 61 523 patients hospitalized between 2005 and 2011 for AMI, CHF, pneumonia, or conditions requiring surgery, Wang et al[8] reported that among patients with AMI, the rate of occurrence of adverse events declined from 5.0% to 3.7% (difference, 1.3%; 95% CI, 0.7%–1.9%). Among patients with CHF, the rate of occurrence of adverse events declined from 3.7% to 2.7% (difference, 1.0%; 95% CI, 0.5%–1.4%). Patients with pneumonia and those with conditions requiring surgery had no significant declines in adverse event rates.

Effectiveness

(See Tables 23-1 through 23-9 and Chart 23-1.)

Effective care has been defined as providing services based on scientific knowledge to all who could benefit and refraining from providing services to those not likely to benefit. It also encompasses monitoring results of the care provided and using them to improve care for all patients.[1]

- Choudhry et al[9] reported results of a cluster randomized trial that evaluated the impact of eliminating out-of-pocket costs (ie, full prescription coverage) on medication adherence and cardiovascular outcomes in patients discharged after MI. Compared with the usual prescription coverage, rates of adherence to statins, β-blockers, ACEIs, and ARBs were on average 4% to 6% higher in the full-coverage group. There was no significant difference in the primary outcome (first major vascular event or revascularization) between the 2 groups (17.6 per 100 person-years in the full-coverage group versus 18.8 in the usual-coverage group; HR, 0.93; 95% CI, 0.82–1.04). The rates of secondary outcomes of total major vascular events or revascularization were significantly reduced in the full-coverage group (21.5 versus 23.3; HR, 0.89; 95% CI, 0.90–0.99), as was the rate of first major vascular event (11 versus 12.8; HR, 0.86; 95% CI, 0.74–0.99). The elimination of copayments did not increase total spending, although patient costs were reduced for drugs and other services.
- Using data from the ACTION Registry among 202 213 patients discharged after AMI from 526 US participating sites between January 2007 and March 2011, Rao and colleagues[10] showed that only 14.5% of the eligible patients without a documented contraindication received aldosterone antagonists. Fewer than 2% of the participating sites used aldosterone antagonists in ≥50% of eligible patients.
- Data from the ACC PINNACLE outpatient registry[11] of patients with CAD (n=38 775) showed that 77.8% of the patients (30 160) were prescribed statins, 5.3% (2042) were treated only with nonstatin lipid-lowering medications, and 17% (6573) were not taking any lipid-lowering medication. Lack of medical insurance (RR, 0.94; 95% CI, 0.89–1.00) was associated with a lower likelihood of statin treatment, whereas male sex (RR, 1.10; 95% CI, 1.07–1.13), coexisting hypertension (RR, 1.07; 95% CI, 1.02–1.12), prior CABG (RR, 1.09; 95% CI, 1.05–1.14), and prior PCI (RR, 1.11; 95% CI, 1.06–1.16) were associated with a higher likelihood of statin treatment. Another publication from the same registry[12] showed that among 156 145 CAD patients in 58 practices, just over two thirds (n=103 830, 66.5%) of patients were prescribed the optimal combination of medications (β-blockers, ACEIs/ARBs, statins) for which they were eligible. After adjustment for patient factors, the practice median rate ratio for prescription was 1.25 (95% CI, 1.20–1.32), which indicates a 25% likelihood that any 2 practices would differ in treating identical CAD patients.[12]
- A recent study from a national cohort of 972 532 CVD patients in the Veterans Health Administration showed that women with CVD (n=13 371) were less likely than men to receive statins (57.6% versus 64.8%, $P<0.0001$) or high-intensity statins (21.1% versus 23.6%, $P<0.0001$) as recommended in the 2013 ACC/AHA cholesterol management guidelines. In adjusted models, female sex was independently associated with a lower likelihood of receiving statins (OR, 0.68; 95% CI, 0.66–0.71) or high-intensity statins (OR, 0.76; 95% CI, 0.73–0.80). The authors concluded that although women with CVD are less likely to receive evidence-based statin and high-intensity statins than men, use of statins remains low in both sexes.[13]

- Heisler et al[14] reported results of a prospective, multisite, cluster randomized trial that evaluated the effectiveness of a pharmacist-led intervention that targeted medication management and adherence counseling to improve BP control in patients with DM in 2 high-performing integrated healthcare systems. Although the mean SBP of patients in the intervention arm was 2.4 mm Hg lower (95% CI, −3.4 to −1.5 mm Hg; $P<0.001$) immediately after the intervention than that of patients in the control arm, the mean SBP decrease from 6 months before to 6 months after the intervention (primary outcome) was similar in magnitude (≈9 mm Hg) in both arms.
- Stub et al[15] reported a post hoc secondary analysis of a large, partial factorial trial of interventions for patients with OHCA. The quality of hospital-based postresuscitation care given to each patient was assigned an evidence-based quality score that considered (1) initiation of temperature management; (2) achievement of target temperature 32° to 34°C; (3) continuation of temperature management for >12 hours; (4) performance of coronary angiography within 24 hours; and (5) no withdrawal of life-sustaining treatment before day 3. These were aggregated as hospital-level composite performance scores, which varied widely (median [IQR] scores from lowest to highest hospital quartiles, 21% [20%–25%] versus 59% [55%–64%]. Adjusted survival to discharge increased with each quartile of composite performance score (from lowest to highest: 16.2%, 20.8%, 28.5%, and 34.8%; $P<0.01$). Adjusted rates of favorable neurological outcome also increased (from lowest quartile to highest: 8.3%, 13.8%, 22.2%, and 25.9%; $P<0.01$). Hospital score was significantly associated with outcome after risk adjustment for established baseline factors (highest versus lowest adherence quartile: adjusted OR of survival, 1.64; 95% CI, 1.13–2.38).
- Using data from the Veterans Affairs CART Program, Maddox and colleagues[16] studied outcomes associated with nonobstructive CAD. Among 37 674 veterans undergoing cardiac catheterization, 8384 (22.3%) had nonobstructive CAD. Compared with veterans with no CAD, 1-, 2-, and 3-vessel nonobstructive CAD was associated with 2 to 4.6 times higher odds of MI. Thus, nonobstructive CAD appears to confer significant risks for MI, and appropriate measures for preventative therapies should be considered.
- In a comparative effectiveness study of single- versus dual-chamber implantable cardioverter-defibrillators using data from the NCDR ICD (implantable cardioverter-defibrillator) Registry, Peterson and colleagues[17] found that among patients receiving an implantable cardioverter-defibrillator for primary prevention without indications for pacing, the use of a dual-chamber device compared with a single-chamber device was associated with a higher risk of device-related complications and similar 1-year mortality and hospitalization outcomes. In a propensity-matched cohort, rates of complications were lower for single-chamber devices (3.51% versus 4.72%; $P<0.001$; risk difference, −1.20 [95% CI, −1.72 to −0.69]), but device type was not significantly associated with 1-year mortality (unadjusted rate, 9.85% versus 9.77%; HR, 0.99 [95% CI, 0.91–1.07]; $P=0.79$), 1-year all-cause hospitalization (unadjusted rate, 43.86% versus 44.83%; HR, 1.00 [95% CI, 0.97–1.04]; $P=0.82$), or hospitalization for HF (unadjusted rate, 14.73% versus 15.38%; HR, 1.05 [95% CI, 0.99–1.12]; $P=0.19$).
- In 2013, investigators from the GBD 2010 study described their findings of a systematic analysis of disease burden, injuries, and leading risk factors in the United States and compared them with those of 34 countries in the Organisation for Economic Co-operation and Development.[18] They reported that the US life expectancy for both sexes combined increased from 75.2 years in 1990 to 78.2 years in 2010. During the same time period, healthy life expectancy (ie, the number of years that a person at a given age can expect to live in good health, taking into account mortality and disability) increased from 65.8 to 68.1 years in the United States. Despite declines in the YLLs because of premature mortality secondary to ischemic HD and stroke, 15.9% of YLLs were related to ischemic HD and 4.3% of YLLs were related to stroke in the United States in 2010, which highlights the continued dominance of CVD in causing premature death. Despite these absolute improvements, the US rank among 34 countries in the Organisation for Economic Co-operation and Development changed from 18th to 27th for the age-standardized death rate, from 20th to 27th for life expectancy at birth, from 14th to 26th for healthy life expectancy, and from 23rd to 28th for the age-standardized YLL. These results indicate that improvements in population health in the United States have not kept pace with advances in population health in other wealthy nations.
- Outcome measures of 30-day mortality and 30-day readmission after hospitalization for AMI, HF, or ischemic stroke have been developed that adjust for patient mix (eg, comorbidities) so that comparisons can be made across hospitals.[19] According to national Medicare data from July 2010 through June 2013
  - —The median (10th, 90th percentile) hospital risk-standardized mortality rate was 14.8% (13.1%, 16.5%) for AMI, 11.9% (10.2%, 13.9%) for HF, and 15.2% (13.2%,17.6%) for ischemic stroke.
  - —The median risk-standardized readmission rate was 17.8% (16.6%, 19.2%) for AMI, 22.6% (20.8%, 24.8%) for HF, and 13.2% (11.9%, 14.9%) for ischemic stroke.
  - —Distinct regional patterns were seen for both measures.
  - —The median risk-standardized mortality rate for AMI admissions declined by 0.9% from 15.3% in 2010 to 2011 to 14.4% in 2012 to 2013.
  - —The median risk-standardized mortality rate for HF admissions fluctuated from 11.8% in 2010 to 2011 to 11.7% in 2010 to 2011 to 12.0% in 2012 to 2013.
  - —The median risk-standardized mortality rate for ischemic stroke admissions declined by 0.5% from 15.5% in 2010 to 2011 to 15.0% in 2012 to 2013.
  - —The median risk-standardized readmission rate for AMI declined by 1.6% from 18.6% in 2010 to 2011 to 17.0% in 2012 to 2013.
  - —The median risk-standardized readmission rate for HF declined by 1.5% from 23.4% in 2010 to 2011 to 21.9% in 2012 to 2013.
  - —The median risk-standardized readmission rate for ischemic stroke declined by 1% from 13.7% in 2010 to 2011 to 12.7% in 2012 to 2013.

- A study of 30 947 patients admitted with ischemic strokes showed that admission to a designated stroke center compared with admission to a nondesignated hospital was associated with more frequent use of thrombolytic therapy (4.8% versus 1.7%, $P<0.001$) and lower 30-day all-cause mortality (10.1% versus 12.5%, $P<0.001$).[20]
- A study of 458 hospitals participating in the STS National Cardiac Database showed that an intervention of receiving quality-improvement educational material designed to influence the prescription rates of 4 medication classes (aspirin, β-blockers, lipid-lowering therapy, and ACEIs) after CABG discharge in addition to site-specific feedback reports led to a significant improvement in adherence for all 4 secondary prevention medications at the intervention sites compared with the control sites.[21]
- Inpatient ACS, HF, and stroke quality-of-care measures data, including trends in care data, where available from national registries, are given in Tables 22-1 through 22-6.
- Selected outpatient quality-of-care measures from the National Committee for Quality Assurance for 2013 appear in Table 23-7.
- Quality-of-care measures for patients who had OHCA and were enrolled in the ROC cardiac arrest registry in 2014 (ROC Investigators, unpublished data, November 23, 2015) are given in Table 23-8. Longitudinal measures are also available (Chart 23-1).
- Quality-of-care measures for patients who had IHCA and were enrolled in the AHA's GWTG-Resuscitation quality-improvement project in 2013 (GWTG-Resuscitation Investigators, unpublished data, September 1, 2014) are given in Table 23-9.

Patient-Centered Care

Patient-centered care has been defined as the provision of care that is respectful of and responsive to individual patient preferences, needs, and values and that ensures that patient values guide all clinical decisions. Dimensions of patient-centered care include the following: (1) Respect for patients' values, preferences, and expressed needs; (2) coordination and integration of care; (3) information, communication, and education; (4) physical comfort; (5) emotional support; and (6) involvement of family and friends. Studies that focused on some of these aspects of patient-centered care are highlighted below.

- The COURAGE trial, which investigated a strategy of PCI plus optimal medical therapy versus optimal medical therapy alone, demonstrated that both groups had significant improvement in health status during follow-up. By 3 months, health status scores had increased in the PCI group compared with the medical therapy group, to 76±24 versus 72±23 for physical limitation ($P=0.004$), 77±28 versus 73±27 for angina stability ($P=0.002$), 85±22 versus 80±23 for angina frequency ($P<0.001$), 92±12 versus 90±14 for treatment satisfaction ($P<0.001$), and 73±22 versus 68±23 for quality of life ($P<0.001$). The PCI plus optimal medical therapy group had a small but significant incremental benefit compared with the optimal medical therapy group early on, but this benefit disappeared by 36 months.[22]
- Vigen et al[23] reported results on 4316 patients with AMI treated at 24 hospitals participating in the TRIUMPH study. They assessed risk-standardized 1-year symptom burden as measured by the Seattle Angina Questionnaire Angina Frequency Score and mortality attributed to the hospital that provided AMI care. Hospital-level variation was assessed by use of median ORs. They observed significant hospital-level variation in risk-adjusted angina (range, 17.7%–29.4%; median OR, 1.34; $P<0.001$) and 1-year mortality (range, 4.9%–8.6%; median OR, 1.30; $P=0.01$). At the hospital level, mortality and angina at 1 year were weakly correlated ($r=0.40$; 95% CI, 0.00–0.68; $P=0.05$). Accounting for the quality of AMI care did not attenuate variation in risk-adjusted 1-year mortality or angina, which suggests that symptom burden should be considered a separate quality domain that is not well captured by current quality metrics.
- Peikes et al[24] reported on 15 care-coordination programs as part of a Medicare demonstration project for patients with CHF, CAD, DM, and other conditions. Thirteen of the 15 programs did not show a difference in hospitalization rates, and none of the programs demonstrated net savings. The interventions tested varied significantly, but the majority of the interventions included patient education to improve adherence to medication, diet, exercise, and self-care regimens and improving care coordination through various approaches. These programs had favorable effects on none of the adherence measures and only a few of the many quality-of-care indicators examined. The authors concluded that programs with substantial in-person contact that target moderately to severely ill patients can be cost-neutral and improve some aspects of care.
- Hernandez et al[25] showed that patients with outpatient follow-up within 7 days of discharge for an HF hospitalization were less likely to be readmitted within 30 days in the GWTG-HF registry of patients who were ≥65 years of age. The median length of stay was 4 days (IQR, 2–6 days), and 21.3% of patients were readmitted within 30 days. At the hospital level, the median percentage of patients who had early follow-up after discharge from the index hospitalization was 38.3% (IQR, 32.4%–44.5%).
- Smolderen et al[26] assessed whether health insurance status affects decisions to seek care for AMI. Uninsured and insured patients with financial concerns were more likely to delay seeking care during AMI and had prehospital delays of >6 hours (48.6% of uninsured patients and 44.6% of insured patients with financial concerns compared with 39.3% of insured patients without financial concerns). Lack of health insurance and financial concerns about accessing care among those with health insurance were each associated with delays in seeking emergency care for AMI.
- A randomized trial tested a multifaceted intervention to improve adherence to 4 cardioprotective medications (clopidogrel, statins, ACEIs/ARBs, and β-blockers) after ACS. A total of 253 patients were randomized to either a multifaceted intervention (including pharmacist-led medication reconciliation and tailoring; patient education; collaborative care between a pharmacist and a patient's primary care provider and/or cardiologist; and 2 types of voice messaging for patient education and medication refill reminder) or to usual care. After a 1-year period, 89.3% of the patients in the intervention group were adherent to the 4 cardioprotective medications (mean proportion of days covered >0.8) compared with 73.9% in the usual care group

(*P*=0.003). A greater proportion of patients in the intervention arm than in the usual care group were adherent to clopidogrel (86.8% versus 70.7%, *P*=0.03), statins (93.2% versus 71.3%, *P*<0.001), and ACEIs/ARBs (93.1% versus 81.7%, *P*=0.03) but not β-blockers (88.1% versus 84.8%, *P*=0.59). There were no statistically significant differences in the proportion of patients who achieved BP or LDL-C level goals.[27]

- Reynolds et al[28] reported results on health-related quality of life after transcatheter aortic valve replacement in inoperable patients with severe aortic stenosis compared with those receiving standard therapy. Health-related quality of life was assessed at baseline and at 1, 6, and 12 months with the Kansas City Cardiomyopathy Questionnaire and the 12-item Short Form-12 General Health Survey. Although the Kansas City Cardiomyopathy Questionnaire summary scores improved in both groups, the extent of improvement was greater in the transcatheter aortic valve replacement group than in the standard-care group at 1 month (mean between-group difference, 13 points; 95% CI, 8–19), with larger benefits at 6 months (mean difference, 21 points; 95% CI, 15–27 points) and 12 months (mean difference, 26 points; 95% CI, 19–33). At 12 months, transcatheter aortic valve replacement patients also reported higher physical and mental health scores on the 12-item Short Form-12 General Health Survey, with a mean difference of 5.7 and 6.4 points, respectively (*P*<0.001 for both comparisons) compared with standard care.

Timely Care

(See Table 23-10.)

The *timely care* domain relates to reducing waits and sometimes harmful delays for both those who receive and those who give care. Timeliness is an important characteristic of any service and is a legitimate and valued focus of improvement in health care and other industries.

- Data from the CRUSADE national quality-improvement initiative showed that median delay from onset of symptoms to hospital presentation for patients presenting with NSTEMI was 2.6 hours and was significantly associated with in-hospital mortality but did not change over time from 2001 to 2006.[29]
- Among patients who underwent primary PCI for STEMI and were enrolled in the CathPCI Registry (n=96 738) in a period that coincided with national efforts to reduce D2B times, median D2B times declined from 83 minutes in the 12 months from July 2005 to June 2006 to 67 minutes in the 12 months from July 2008 to June 2009. This improvement in processes of care was not associated with improved outcome (risk-adjusted in-hospital mortality 5.0% in 2005–2006 versus 4.7% in 2008–2009, *P*=0.34).[30]
- Using data between 2005 and 2007 from the NCDR CathPCI Registry, Wang et al[31] demonstrated that among STEMI patients, only 10% of the transfer patients received PCI within 90 minutes (versus 63% for direct-arrival patients; *P*<0.0001).
- Glickman et al[32] showed that a year-long implementation of standardized protocols as part of a statewide regionalization program was associated with a significant improvement in median door-in–door-out times among 436 STEMI patients who presented at non-PCI hospitals who required transfer (before intervention: 97 minutes [IQR, 56–160 minutes]; after intervention: 58 minutes [IQR, 35–90 minutes]; *P*<0.0001).
- Nallamothu et al[33] evaluated the association between D2B times and mortality after primary PCI over time at both the hospital and the individual patient level among 150 116 STEMI patients from 423 hospitals who underwent primary PCI between January 1, 2005, and December 31, 2011, in the NCDR CathPCI Registry. Annual D2B times decreased significantly from a median of 86 minutes (IQR, 65–109 minutes) in 2005 to 63 minutes (IQR, 47–80 minutes) in 2011 (*P*<0.0001), with a concurrent rise in risk-adjusted in-hospital mortality (from 4.7% to 5.3%; *P*=0.06) and risk-adjusted 6-month mortality (from 12.9% to 14.4%; *P*=0.001). In multilevel models, shorter patient-specific D2B times were consistently associated at the individual level with lower in-hospital mortality (adjusted OR for each 10-minute decrease, 0.92; 95% CI, 0.91–0.93; *P*<0.0001) and 6-month mortality (adjusted OR for each 10-minute decrease, 0.94; 95% CI, 0.93–0.95; *P*<0.0001). By contrast, risk-adjusted in-hospital and 6-month mortality at the population level, independent of patient-specific D2B times, rose in the growing and changing population of patients undergoing primary PCI during the study period. These authors concluded that the absence of an association of annual D2B time and changes in mortality at the population level should not be interpreted as an indication of its individual-level relation in patients with STEMI undergoing primary PCI.[33]
- A study of 204 591 patients with ischemic and hemorrhagic strokes admitted to 1563 GTWG-Stroke participating hospitals between April 1, 2003, and June 30, 2010, showed that 63.7% of the patients arrived at the hospital by EMS. Older patients, those with Medicaid and Medicare, and those with severe strokes were more likely to activate EMS. Conversely, minority race/ethnicity (black, Hispanic, Asian) and living in rural communities were associated with a lower likelihood of EMS use. EMS transport was independently associated with an onset-to-door time ≤3 hours, a higher proportion of patients meeting door-to-imaging time of ≤25 minutes, more patients meeting a door-to-needle time of ≤60 minutes, and more eligible patients being treated with tPA if onset of symptoms was ≤2 hours. The authors concluded that although EMS use was associated with rapid evaluation and treatment of stroke, more than one third of stroke patients fail to use EMS.[34]
- Data on time to reperfusion for STEMI or ischemic stroke are provided from national registries in Table 23-10.

Efficiency

Efficiency has been defined as avoiding waste, in particular waste of equipment, supplies, ideas, and energy. In an efficient healthcare system, resources are used to get the best value for the money spent.

- Using data from the NCDR CathPCI registry from 2004 through 2010, Amin et al[35] examined the association between risk of TVR and use of DES and the cost-effectiveness of lower use of DES in patients at low risk of TVR (<10% TVR risk). The authors showed a marked

variation in physicians' use of DES (range, 2%–100%). Even in groups with low TVR risk, 73.9% of the patients received DES. The authors projected that by reducing the use of DES by 50% in patients at low risk of TVR, US healthcare costs could be lowered by $205 million, whereas the overall TVR event rate would be increased by 0.5%.

- A study of 35 191 CHD patients from the US Department of Veterans Affairs healthcare system showed that among 27 947 patients with LDL-C levels <100 mg/dL, 9200 (32.9%) received additional lipid assessments without any treatment intensification during the 11 months from the index lipid panel. Even among 13 114 patients with LDL-C <70 mg/dL, repeat lipid testing was performed in 8177 patients (62.4%) during 11 months of follow-up. These results show that redundant lipid testing is common in patients with CHD.[36]
- Himmelstein et al[37] analyzed whether more-computerized hospitals had lower costs of care or administration or better quality, to address a common belief that computerization improves healthcare quality, reduces costs, and increases administrative efficiency. They found that hospitals that increased computerization faster had more rapid administrative cost increases (P=0.0001); however, higher overall computerization scores correlated weakly with better quality scores for AMI (r=0.07, P=0.003) but not for HF, pneumonia, or the 3 conditions combined. In multivariate analyses, more-computerized hospitals had slightly better quality. The authors concluded that hospital computing might modestly improve process measures of quality but does not reduce administrative or overall costs.
- In a retrospective cohort study of cases (111 707) submitted to the NCDR ICD (implantable cardioverter-defibrillator) Registry between January 1, 2006, and June 30, 2009, 25 145 (22.5%) received non–evidence-based implantable cardioverter-defibrillator therapy. Patients who received non–evidence-based implantable cardioverter-defibrillator therapy had a significantly higher risk of in-hospital death (0.57% versus 0.18%, P<0.001) and any postprocedure complication (3.23% versus 2.41%, P<0.001) than those who received evidence-based implantable cardioverter-defibrillator therapy.[38]
- In a multicenter study of patients within the NCDR undergoing PCI, Chan et al[39] reported results of the appropriateness of PCI for both acute and nonacute indications. Among patients undergoing PCI for acute indications (71.1% of the cohort), 98.5% of the procedures were classified as appropriate, 0.3% as uncertain, and 1.1% as inappropriate. Among patients undergoing PCI for nonacute indications (28.9% of the cohort), 50.4% of the procedures were classified as appropriate, 38% as uncertain, and 11.6% as inappropriate. There was also substantial variation for inappropriate nonacute PCI across hospitals (median hospital rate, 10.8%; IQR, 6.0%–16.7%).

Equitable Care

(See Tables 23-11 through 23-13.)

Equitable care means the provision of care that does not vary in quality because of personal characteristics such as sex, ethnicity, geographic location, and socioeconomic status. The aim of equity is to secure the benefits of quality health care for all the people of the United States. With regard to equity in caregiving, all individuals rightly expect to be treated fairly by local institutions, including healthcare organizations.

- Chan et al[40] demonstrated that rates of survival to discharge were lower for black patients (25.2%) than for white patients (37.4%) after in-hospital cardiac arrest. Lower rates of survival to discharge for blacks reflected lower rates of both successful resuscitation (55.8% versus 67.4%) and postresuscitation survival (45.2% versus 55.5%). Adjustment for the hospital site at which patients received care explained a substantial portion of the racial differences in successful resuscitation (adjusted RR, 0.92; 95% CI, 0.88–0.96; P<0.001) and eliminated the racial differences in postresuscitation survival (adjusted RR, 0.99; 95% CI, 0.92–1.06; P=0.68). The authors concluded that much of the racial difference was associated with the hospital center in which black patients received care.
- Davis et al[41] recently evaluated data on 85 936 veterans (3181 women) undergoing initial cardiac catheterization between October 1, 2007, and September 30, 2012, in the Veterans Health Administration. Women had lower rates of obstructive CAD than men (22.6% versus 53.3%). Rates of procedural complications were similar in both sexes. Adjusted outcomes at 1 year showed women had lower mortality (HR, 0.74; 95% CI, 0.60–0.92) and less all-cause rehospitalization (HR, 0.87; 95% CI, 0.82–0.93), but there was no difference in rates of unplanned PCI.
- Kapoor et al[42] evaluated 99 058 HF admissions from 244 sites between January 2005 and September 2009. Patients were grouped on the basis of payer status (private/health maintenance organization, no insurance, Medicare, or Medicaid). Compared with private/health maintenance organization group, the other 3 groups were less likely to receive evidence-based therapies (β-blockers, implantable cardioverter-defibrillators, anticoagulation for AF, ACEIs, or ARBs) and had longer hospital stays. Higher adjusted rates of in-hospital mortality were also seen in patients with Medicaid (OR, 1.22; 95% CI, 1.06–1.41) and in patients with reduced EF and no insurance (OR, 1.61; 95% CI, 1.15–2.25).
- Cohen et al[43] demonstrated that among hospitals engaged in a national quality monitoring and improvement program, evidence-based care for AMI appeared to improve over time for patients irrespective of race/ethnicity, and differences in care by race/ethnicity care were reduced or eliminated. They analyzed 142 593 patients with AMI (121 528 whites, 10 882 blacks, and 10 183 Hispanics) at 443 hospitals participating in the GWTG-CAD program. Overall, defect-free care was 80.9% for whites, 79.5% for Hispanics (adjusted OR versus whites, 1.00; 95% CI, 0.94–1.06; P=0.94), and 77.7% for blacks (adjusted OR versus whites, 0.93; 95% CI, 0.87–0.98; P=0.01). A significant gap in defect-free care was observed for blacks during the first half of the study but was no longer present during the remainder of the study. Overall, progressive improvements in defect-free care were observed regardless of race/ethnic groups.
- Thomas et al[44] analyzed data among hospitals that voluntarily participated in the AHA's GWTG-HF program from January 2005 through December 2008. Relative to white patients, Hispanic and black patients hospitalized with HF were significantly younger (median age 78, 63, and 64

years, respectively) but had lower EFs (mean EF 41.1%, 38.8%, and 35.7%, respectively) with a higher prevalence of DM (40.2%, 55.7%, and 43.8%, respectively) and hypertension (70.6%, 78.4%, and 82.8%, respectively). The provision of guideline-based care was comparable for white, black, and Hispanic patients. Black (1.7%) and Hispanic (2.4%) patients had lower in-hospital mortality than white patients (3.5%). Improvement in adherence to all-or-none HF measures increased annually from year 1 to year 3 for all 3 racial/ethnic groups.

- Al-Khatib et al[45] analyzed implantable cardioverter-defibrillator use for primary prevention among 11 880 patients with a history of HF, LV EF <35%, and age >65 years enrolled in the GWTG-HF registry from January 2005 through December 2009. From 2005 to 2007, overall implantable cardioverter-defibrillator use increased from 30.2% to 42.4% and then remained unchanged in 2008 to 2009. After adjustment for confounders, implantable cardioverter-defibrillator use increased significantly in the overall study population during 2005 to 2007 (OR, 1.28; 95% CI, 1.11–1.48 per year; *P*=0.0008) and in black women (OR, 1.82; 95% CI, 1.28–2.58 per year; *P*=0.0008), white women (OR, 1.30; 95% CI, 1.06–1.59 per year; *P*=0.010), black men (OR, 1.54; 95% CI, 1.19–1.99 per year; *P*=0.0009), and white men (OR, 1.25; 95% CI, 1.06–1.48 per year; *P*=0.0072). The increase in implantable cardioverter-defibrillator use was greatest among blacks. They concluded that although previously described racial disparities in the use of implantable cardioverter-defibrillators were no longer present in their study by the end of the study period, a sex difference in their use persisted.
- In 2013, the AHA published an advisory that provided a recommendation on improving bystander cardiopulmonary resuscitation in communities with low bystander cardiopulmonary resuscitation rates (in the United States, rates ranged from 10%–65%) and the metrics to evaluate the impact of community-based cardiopulmonary resuscitation training programs.[46]

Table 23-1. ACS Quality-of-Care Measures, 2014

Quality-of-Care Measure	VHA*	ACTION-GWTG STEMI†	ACTION-GWTG NSTEMI†
Aspirin within 24 h of admission	99	98.5	97.9
Aspirin at discharge	99	99.1	98.4
β-Blockers at discharge	99	98.2	97.2
Lipid-lowering medication at discharge‡	99	99.4	98.9
ARB/ACEI at discharge for patients with LVEF <40%	96	93.0	89.8
ACEI at discharge for AMI patients	NM	69.4	56.5
ARB at discharge for AMI patients	NM	10.5	14.9
Adult smoking cessation advice/counseling	Retired	98.9	98.4
Cardiac rehabilitation referral for AMI patients	NM	84.5	75.9

Values are percentages. ACEI indicates angiotensin-converting enzyme inhibitor; ACS, acute coronary syndrome; ACTION-GWTG, Acute Coronary Treatment and Intervention Outcomes Network Registry–Get With The Guidelines; AMI, acute myocardial infarction; ARB, angiotensin receptor blocker; LVEF, left ventricular ejection fraction; NM, not measured; NSTEMI, non–ST-segment–elevation myocardial infarction; STEMI, ST-segment–elevation myocardial infarction; and VHA, Veterans Health Administration.

*VHA: AMI patients. Data reported include data from October 1, 2013, to September 30, 2014.

†ACTION Registry: STEMI and NSTEMI patients are reported separately. Patients must be admitted with acute ischemic symptoms within the previous 24 hours, typically reflected by a primary diagnosis of STEMI or NSTEMI. Patients who are admitted for any other clinical condition are not eligible. Data reported include data from the first quarter of 2014 to the fourth quarter of 2014.

‡Denotes statin use at discharge. Use of nonstatin lipid-lowering agent was 5.2% for STEMI patients and 8.6% for NSTEMI patients in the ACTION registry.

Table 23-2. HF Quality-of-Care Measures, 2014

Quality-of-Care Measure	AHA GWTG-HF	VHA
LVEF assessment	99.0	100
ARB/ACEI at discharge for patients with LVSD	95.3	97
Complete discharge instructions	95.7	96
β-Blockers at discharge for patients with LVSD, no contraindications	97.9	NM
Anticoagulation for AF or atrial flutter, no contraindications	82.2	Retired

Values are percentages. ACEI indicates angiotensin-converting enzyme inhibitor; AF, atrial fibrillation; AHA, American Heart Association; GWTG-HF, Get With The Guidelines–Heart Failure; ARB, angiotensin receptor blocker; HF, heart failure; LVEF, left ventricular ejection fraction; LVSD, left ventricular systolic dysfunction; NM, not measured; and VHA, Veterans Health Administration.

Table 23-3. Time Trends in GWTG-ACS Quality-of-Care Measures, 2006 to 2014

Quality-of-Care Measure	2006	2007	2008	2009	2010*	2011*	2012*	2013*	2014*
Aspirin within 24 h of admission	94.7	92.8	91.2	90.9	97	97.6	97.8	95.4	98.1
Aspirin at discharge	94.4	95.8	94.9	95.5	98	98.3	98.4	98.4	98.7
β-Blockers at discharge	92.8	94.6	94.5	94.9	96	96.7	97.1	97.1	97.6
Lipid-lowering medication at discharge	84.5	85.6	81.6	86.8	92†	98.4†	98.8†	98.8	99.1
Lipid therapy at discharge if LDL-C >100 mg/dL	89.1	90.7	91.9	92.5	NM	NM	NM	NM	NM
ARB/ACEI at discharge for patients with LVEF <40%	87.3	91.1	91.9	91.9	86	87.8	89.7	90.0	91.2
Adult smoking cessation advice/counseling	94.3	97.4	98.4	98.4	98	98.4	98.4	98.4	98.6
Cardiac rehabilitation referral for AMI patients	71.1	63.6	52.0	49.1	75	76.5	77.3	77.2	79.4

Values are percentages. In the ACTION (Acute Coronary Treatment and Intervention Outcomes Network) registry, the unadjusted in-hospital mortality rate for 2013 was 4.6% (95% confidence interval, 4.5%–4.7%; excludes transfer-out patients). The American Heart Association's Get With The Guidelines–Coronary Artery Disease (GWTG-CAD) program has merged into the ACTION registry. ACEI indicates angiotensin-converting enzyme inhibitor; AMI, acute myocardial infarction; ARB, angiotensin receptor blocker; GWTG-ACS, Get With The Guidelines–Acute Coronary Syndrome; LDL-C, low-density lipoprotein cholesterol; LVEF, left ventricular ejection fraction; and NM, not measured.

*Measures from 2006 to 2009 are from the American Heart Association's GWTG-CAD registry. The 2010 to 2014 measures are from the American Heart Association's ACTION registry.

†Represents statin use. Use of nonstatin lipid-lowering agent was 7.3% for all patients in the ACTION registry-GWTG.

Table 23-4. Time Trends in GWTG-HF Quality-of-Care Measures, 2006 to 2014

Quality-of-Care Measure	2006	2007	2008	2009	2010	2011	2012	2013	2014
LVEF assessment*	93.5	95.5	96.4	98.0	98.0	96.6	96.5	99.0	99.0
ARB/ACEI at discharge for patients with LVSD*	85.4	89.1	91.5	92.9	94.2	95.2	95.4	95.6	95.3
Postdischarge appointment (new for 2011)*	…	…	…	…	…	16.3	47.4	61.3	67.7
Complete discharge instructions	91.0	94.9	97.2	97.7	99.3	93.8	93.4	94.1	95.7
Evidence-based specific β-blockers*	67.7	58.9	54.1	45.2	48.4	57.1	82.6	86.6	91.1
β-Blockers at discharge for patients with LVSD, no contraindications	90.0	90.4	92.6	92.5	94.8	96.0	97.2	97.7	97.9
Anticoagulation for AF or atrial flutter, no contraindications	62.3	61.2	60.5	68.8	70.2	75.9	78.7	80.1	82.2

Values are percentages. ACEI indicates angiotensin-converting enzyme inhibitor; AF, atrial fibrillation; ARB, angiotensin receptor blocker; GWTG-HF, Get With The Guidelines–Heart Failure; LVEF, left ventricular ejection fraction; and LVSD, left ventricular systolic dysfunction.

*Indicates the 4 key achievement measures targeted in GWTG-HF. The composite quality-of-care measure for 2014 was 96.9%. The composite quality-of-care measure indicates performance on the provision of several elements of care. It is computed by summing the numerators for each key achievement measure across the population of interest to create a composite numerator (all the care that was given), summing the denominators for each measure to form a composite denominator (all the care that should have been given), and reporting the ratio (the percentage of all the needed care that was given). The composite performance measure includes β-blocker at discharge instead of evidence-based specific β-blockers and complete discharge instructions instead of postdischarge appointment until the data collection for the new achievement measures stabilizes.

Table 23-5. Time Trends in GWTG-Stroke Quality-of-Care Measures, 2006 to 2014

Quality-of-Care Measure	2006	2007	2008	2009	2010	2011	2012	2013	2014
IV tPA in patients who arrived ≤2 h after symptom onset, treated ≤3 h*	56.0	60.5	64.4	73.9	76.2	78.3	82.0	83.3	86.4
IV tPA in patients who arrived <3.5 h after symptom onset, treated ≤4.5 h	…	…	…	…	42.5	57.9	60.4	64.3	72.3
IV tPA door-to-needle time ≤60 min	22.5	24.9	25.9	28.0	29.5	33.8	39.9	59.3	66.2
Antithrombotic agents <48 h after admission*	94.9	95.8	96.0	96.1	96.3	96.7	96.9	97.0	97.2
DVT prophylaxis by second hospital day*	85.4	88.9	92.2	92.7	92.2	93.5	98.4	98.3	98.7
Antithrombotic agents at discharge*	94.1	95.1	97.0	97.8	97.7	98.1	97.8	97.6	98.0
Anticoagulation for atrial fibrillation at discharge*	88.2	89.5	93.1	93.5	93.5	93.1	93.4	93.6	94.8
Therapy at discharge if LDL-C >100 mg/dL or LDL-C not measured or on therapy at time of admission*	61.6	67.5	73.4	88.1	89.0	89.8	94.5	95.9	96.9
Counseling for smoking cessation*	86.1	92.1	94.3	96.3	96.7	97.0	96.8	96.3	96.5
Composite quality-of-care measure	83.1	86.1	89.7	94.7	94.2	94.4	96.3	96.4	96.9

Values are percentages. DVT indicates deep vein thrombosis; GWTG, Get With The Guidelines; IV, intravenous; LDL-C, low-density lipoprotein cholesterol; and tPA, tissue-type plasminogen activator.

*Indicates the 7 key achievement measures targeted in GWTG-Stroke.

Table 23-6. Additional ACTION-GWTG Quality-of-Care Metrics for ACS Care, 2014

Quality Metrics	Overall	STEMI	NSTEMI
ECG within 10 min of arrival	65.4	75.6	60.9
Aspirin within 24 h of arrival	98.1	98.5	97.9
Any anticoagulant use*	94.2	96.4	92.7
Dosing error			
UFH dose	45.7	44.6	45.7
Enoxaparin dose	9.9	7.6	10.0
Glycoprotein IIb/IIIa inhibitor dose	6.0	6.0	5.8
Aspirin at discharge	98.7	99.1	98.4
Prescribed statins on discharge	99.1	99.4	98.9
Adult smoking cessation advice/counseling	98.6	98.9	98.4
Cardiac rehabilitation referral	79.4	84.5	75.9
In-hospital mortality† (95% CI)	4.6 (4.5–4.7)	6.4 (6.2–6.6)	3.4 (3.3–3.5)

Values are percentages. ACS indicates acute coronary syndrome; ACTION-GWTG, Acute Coronary Treatment and Intervention Outcomes Network Registry–Get With The Guidelines; CI, confidence interval; ECG, electrocardiogram; NSTEMI, non–ST-segment–elevation myocardial infarction; STEMI, ST-segment–elevation myocardial infarction; and UFH, unfractionated heparin.

Data reported include data from the first quarter of 2014 to the fourth quarter of 2014.

*Includes UFH, low-molecular-weight heparin, or direct thrombin inhibitor use.

†Excludes transfer-out patients.

Table 23-7. National Committee for Quality Assurance Health Plan Employer Data and Information Set Measures of Care, 2013

	Commercial		Medicare		
	HMO	PPO	HMO	PPO	Medicaid (HMO)
AMI					
β-Blocker persistence*	83.9	81.4	90	89.4	84.2
Cholesterol management for patients with CVD					
LDL-C screening	86.7	82.6	89.6	87.9	81.1
LDL-C control (<100 mg/dL)	57.5	50.2	58.6	56.1	40.5
BP <140/90 mm Hg	64.4	57.6	65.5	62.5	56.5
DM					
HbA_{1c} testing	89.9	87.3	92.3	91.7	83.8
HbA_{1c} >9.0%	30.5	37.6	25.3	26.6	45.6
Eye examination performed	55.7	46.9	68.5	66	53.6
LDL-C screening	84.9	81.3	88.9	87.7	76
LDL-C <100 mg/dL	46.7	40.8	53.8	52.7	33.9
Monitoring nephropathy	84.5	78.8	91.1	89.4	79.0
BP <140/90 mm Hg	65.0	58.5	65.6	62.2	60.4
Advising smokers and tobacco users to quit	77.3	70.9	N/A	N/A	75.8
BMI percentile assessment in children and adolescents	57.7	33.2	N/A	N/A	56.9
Nutrition counseling (children and adolescents)	56.7	36.1	N/A	N/A	58.7
Counseling for physical activity (children and adolescents)	53.6	33.8	N/A	N/A	50.5
BMI assessment for adults	75.7	41.4	89.6	84.9	75.9
Physical activity discussion in older adults (≥65 y of age)	N/A		55.1	55.2	N/A
Physical activity advice in older adults (≥65 y of age)	N/A		50.4	48.2	N/A

Values are percentages. AMI indicates acute myocardial infarction; BMI, body mass index; BP, blood pressure; CVD, cardiovascular disease; DM, diabetes mellitus; HbA_{1c}, hemoglobin A_{1c}; HMO, health maintenance organization; LDL-C, low-density lipoprotein cholesterol; N/A, not available or not applicable; and PPO, preferred provider organization.

*β-Blocker persistence: Received persistent β-blocker treatment for 6 months after AMI hospital discharge.

Table 23-8. Quality of Care for Patients With Out-of-Hospital Cardiac Arrest at US ROC Sites (January 1, 2014 to December 31, 2014)

	Overall	Adults	Children
Bystander and EMS care*			
Bystander CPR, %	46.1 (45.0–47.3)	45.7 (44.6–46.9)	61.4 (54.9–67.9)
Shocked by AED before EMS, %	2.0 (1.7–2.4)	2.1 (1.7–2.4)	1.4 (0.0–3.0)
Chest compression fraction during first 5 min of CPR (%)	0.85 (0.12)	0.85 (0.12)	0.83 (0.13)
Compression depth (mm)	48.1 (10.7)	48.1 (10.7)	47.2 (9.5)
Preshock pause duration (s)	10.8 (11.0)	10.8 (10.9)	16.2 (16.4)
Time to first EMS defibrillator applied (min)	8.8 (4.5)	8.8 (4.5)	8.7 (4.2)
Hospital-based metrics†			
Hypothermia induced after initial VT/VF, %‡	66.3 (62.3–70.3)	66.2 (62.1–70.2)	100 (100–100)
No order for withdrawal/DNR during first 72 h, %§	45.0 (42.1–48.0)	44.8 (41.9–47.8)	100 (100–100)
Implantable cardioverter-defibrillator assessment, initial VT/VF, no AMI per MD notes or final ECG interpretation, %‖	30.3 (24.8–35.8)	30.0 (24.5–35.6)	100 (100-100)

Values are mean (95% confidence interval) or mean (SD). Because age is missing for some cases, these cases are not included in either adults or children, thus explaining why overall rates equal the adult rates when rates for children are not available. AED indicates automated external defibrillator; AMI, acute myocardial infarction; CPR, cardiopulmonary resuscitation; DNR, do not resuscitate; ECG, electrocardiogram; EMS, emergency medical services; MD, medical doctor; ROC, Resuscitation Outcomes Consortium; SD, standard deviation; and VT/VF, ventricular tachycardia/ventricular fibrillation.

*Data are from EMS-treated cases.

†During 2014, there was 1 pediatric case with initial rhythm VT/VF admitted to the hospital.

‡Denominator is all cases with initial rhythm VT/VF and admitted to the hospital.

§Denominator is all cases admitted to the hospital.

‖Denominator is all cases with initial rhythm VT/VF, no indication of AMI, no percutaneous coronary intervention, no bypass, and admitted to the hospital.

Table 23-9. Quality of Care of Patients With In-Hospital Cardiac Arrest Among GWTG-Resuscitation Hospitals, 2014

	Adults	Children
Event outside critical care setting	48.1	11.2
All objective CPR data collected	78.6	82.0
$ETco_2$ used during arrest	4.6	23.0
Induced hypothermia after resuscitation from shockable rhythm	7.6	13.6

Values are mean percentages. CPR indicates cardiopulmonary resuscitation; $ETCO_2$, end-tidal CO_2; and GWTG, Get With The Guidelines.

Source: GWTG-Resuscitation Investigators, June 2015.

Table 23-10. Timely Reperfusion for ACS and Stroke, 2014

Quality-of-Care Measure	VHA (for STEMI) or GWTG-Stroke (for Stroke)	ACTION-GWTG STEMI*
STEMI		
Thrombolytics within 30 min	100†	54.0†
PCI within 90 min	72	95.9
Stroke		
IV tPA in patients who arrived <2 h after symptom onset, treated ≤3 h	83.8	N/A
IV tPA in patients who arrived <3.5 h after symptom onset, treated ≤4.5 h	64.3	N/A
IV tPA door-to-needle time ≤60 min	59.3	N/A

Values are percentages. ACS indicates acute coronary syndrome; ACTION, Acute Coronary Treatment and Intervention Outcomes Network Registry; GWTG, Get With The Guidelines; IV, intravenous; N/A, not applicable; PCI, percutaneous coronary intervention; STEMI, ST-segment–elevation myocardial infarction; tPA, tissue-type plasminogen activator; and VHA, Veterans Health Administration.

*ACTION Registry: data reported include data from October 1, 2013 to September 30, 2014.

†Indicates low number.

Table 23-11. Quality of Care by Race/Ethnicity and Sex in the ACTION Registry, 2012

Quality-of-Care Measure	White	Black	Other	Men	Women
Aspirin at admission	98.1	98.2	98.3	98.4	97.7
Aspirin at discharge	98.8	98.0	98.8	98.9	98.2
β-Blockers at discharge	97.6	97.2	97.5	97.9	97.0
Time to PCI ≤90 min for STEMI patients	96.1	94.3	96.0	96.2	95.2
ARB/ACEI at discharge for patients with LVEF <40%	91.2	91.7	88.5	91.5	90.5
Statins at discharge	99.1	98.9	99.4	99.3	98.8

Values are percentages. Data reported include data from first quarter of 2014 to fourth quarter of 2014. ACEI indicates angiotensin-converting enzyme inhibitor; ACTION, Acute Coronary Treatment and Intervention Outcomes Network; ARB, angiotensin receptor blocker; LVEF, left ventricular ejection fraction; PCI, percutaneous coronary intervention; and STEMI, ST-segment–elevation myocardial infarction.

Table 23-12. Quality of Care by Race/Ethnicity and Sex in the GWTG-HF Program, 2013

Quality-of-Care Measure	White	Black	Hispanic	Men	Women
Postdischarge appointment (new for 2011)*	62.6	64.8	62.7	63.8	62.5
Complete set of discharge instructions†	94.3	95.2	95.2	94.8	94.1
Measure of LV function*	99.4	99.3	99.3	99.4	99.2
ACEI or ARB at discharge for patients with LVSD, no contraindications*	95.6	96.6	96.1	96.0	96.0
Smoking cessation counseling, current smokers†	96.3	95.7	96.0	96.1	95.6
Evidence-based specific β-blockers*	89.2	92.0	89.2	90.6	89.3
β-Blockers at discharge for patients with LVSD, no contraindications†	97.8	98.2	98.3	98.0	97.9
Hydralazine/nitrates at discharge for patients with LVSD, no contraindications‡	…	19.9	…	21.4	17.5
Anticoagulation for AF or atrial flutter, no contraindications	81.3	79.0	76.3	81.7	79.3
Composite quality-of-care measure (using discharge instructions and β-blocker at discharge)	96.8	97.0	97.1	96.8	96.6

Values are percentages. ACEI indicates angiotensin-converting enzyme inhibitor; AF, atrial fibrillation; ARB, angiotensin receptor blocker; GWTG-HF, Get With The Guidelines–Heart Failure; LV, left ventricular; and LVSD, left ventricular systolic dysfunction.

*Indicates the 4 key achievement measures targeted in GWTG-HF.

†Indicates historical key achievement measures in GWTG-HF.

‡For black patients only.

Table 23-13. Quality of Care by Race/Ethnicity and Sex in the GWTG-Stroke Program, 2013

Quality-of-Care Measure	White	Black	Hispanic	Male	Female
IV tPA in patients who arrived ≤2 h after symptom onset, treated ≤3 h*	86.2	85.4	88.1	87.1	85.6
IV tPA in patients who arrived <3.5 h after symptom onset, treated ≤4.5 h	64.7	65.6	69.9	66.6	64.1
IV tPA door-to-needle time ≤60 min	59.1	59.5	62.7	60.8	58.6
Thrombolytic complications: IV tPA and life-threatening, serious systemic hemorrhage	16.3	20.0	8.3	14.7	18.1
Antithrombotic agents <48 h after admission*	97.4	97.1	97.3	97.5	97.1
DVT prophylaxis by second hospital day*	98.4	98.2	98.2	98.3	98.4
Antithrombotic agents at discharge*	98.3	97.8	97.7	98.3	97.9
Anticoagulation for atrial fibrillation at discharge*	94.3	94.3	94.8	94.6	94.0
Therapy at discharge if LDL-C >100 mg/dL or LDL-C not measured or on therapy at admission*	96.0	96.4	96.0	96.7	95.5
Counseling for smoking cessation*	96.8	96.5	95.9	96.8	96.4
Lifestyle changes recommended for BMI >25 kg/m^2	55.5	52.6	57.5	55.2	54.6
Composite quality-of-care measure	96.9	96.8	96.7	97.1	96.6

Values are percentages. BMI indicates body mass index; DVT, deep vein thrombosis; GWTG, Get With The Guidelines; IV, intravenous; LDL-C, low-density lipoprotein cholesterol; and tPA, tissue-type plasminogen activator.

*Indicates the 7 key achievement measures targeted in GWTG-Stroke.

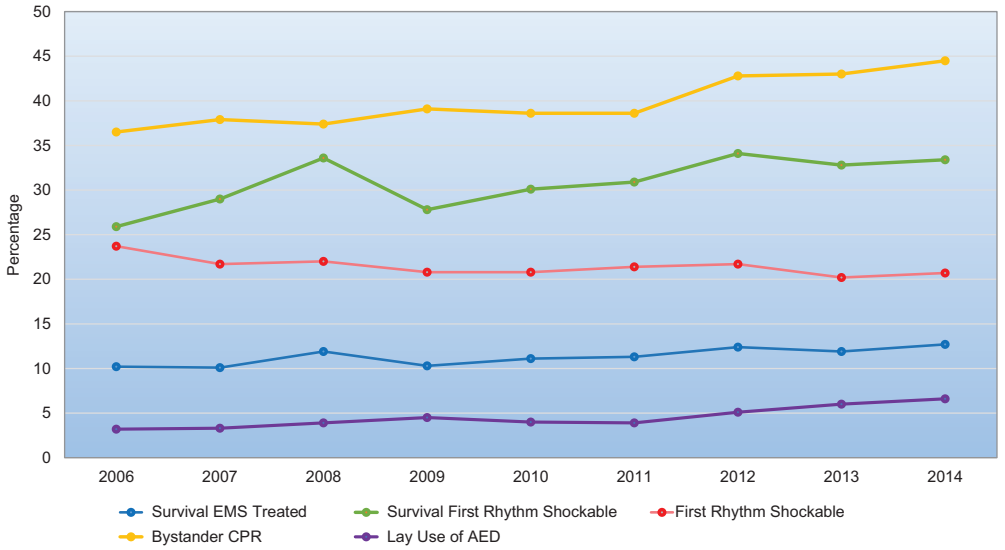

Chart 23-1. Survival rates after out-of-hospital cardiac arrest in US sites of Resuscitation Outcomes Consortium, 2006 to 2014. AED indicates automated external defibrillator; CPR, cardiopulmonary resuscitation; and EMS, emergency medical services.

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24. Medical Procedures

See Tables 24-1 and 24-2 and Charts 24-1 through 24-4.

Trends in Operations and Procedures

(See Tables 24-1 and 24-2 and Charts 24-1 and 24-2.)

- The total number of inpatient cardiovascular operations and procedures increased 28%, from 5 939 000 in 2000 to 7 588 000 in 2010 (NHLBI computation based on NCHS annual data). Data from the NHDS were examined for trends from 1990 to 2004 for use of PCI and CABG and in-hospital mortality rate attributable to PCI and CABG by sex[1]:
  - —Discharge rates (per 10 000 population) for PCI increased 58%, from 37.2 in 1990 to 1992 to 59.2 in 2002 to 2004.
  - —Discharge rates for CABG increased from 34.1 in 1990 to 1992 to 38.6 in 1996 to 1998, then declined to 25.2 in 2002 to 2004.
  - —In 1990 to 1992, discharge rates for CABG were 53.5 for males and 18.1 for females; these rates increased through 1996 to 1998, then declined to 38.8 and 13.6, respectively, in 2002 to 2004. The magnitude of these declines decreased by age decile and were essentially flat for both men and women ≥75 years of age.
  - —PCI discharge rates increased from 54.5 for males and 23.0 for females to 83.0 and 38.7, respectively, over the 15-year time interval. In 2002 to 2004, discharge rates for men and women 65 to 74 years of age were 135.1 and 64.0, respectively. For those ≥75 years of age, the rates were 128.7 and 69.0, respectively.
  - —In-hospital mortality rate (deaths per 100 CABG discharges) declined from 4.3 to 3.5 between 1990 to 1992 and 2002 to 2004 despite an increase in Charlson comorbidity index. The mortality rate declined in all age and sex subsets, but especially in women.
- Data from the Acute Care Tracker database were used to estimate the population-based rates per 100 000 population for PCI and CABG procedures from 2002 to 2005, standardized to the 2005 US population[2]:
  - —Adjusted for age and sex, the overall rate for coronary revascularization declined from 382 to 358 per 100 000. PCI rates during hospitalization increased from 264 to 267 per 100 000, whereas CABG rates declined from 121 to 94 per 100 000.
- Data on Medicare beneficiaries undergoing a coronary revascularization procedure between 2008 and 2012 indicate that the rapid growth in nonadmission PCIs (from 60 405 to 106 495) has been more than offset by the decrease in PCI admissions (from 363 384 to 295 434).[3]

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Abbreviations Used in Chapter 24

ASD	atrial septal defect
CABG	coronary artery bypass graft
DES	drug-eluting stent
GWTG-CAD	Get With the Guidelines–Coronary Artery Disease
HCUP	Healthcare Cost and Utilization Project
HLHS	hypoplastic left heart syndrome
ICD-9-CM	*International Classification of Diseases, 9th Revision, Clinical Modification*
NCHS	National Center for Health Statistics
NHDS	National Hospital Discharge Survey
NHLBI	National Heart, Lung, and Blood Institute
PCI	percutaneous coronary intervention
PTCA	percutaneous transluminal coronary angioplasty
STEMI	ST-segment–elevation myocardial infarction
STS	Society of Thoracic Surgeons
VSD	ventricular septal defect

Cardiac Catheterization and PCI

(See Tables 24-1 and 24-2.)

- From 2000 to 2010, the number of cardiac catheterizations decreased slightly, from 1 221 000 to 1 029 000 annually (NHDS, NHLBI tabulation).
- In 2010, an estimated 492 000 patients underwent PCI (previously referred to as percutaneous transluminal coronary angioplasty, or PTCA) procedures in the United States (NHDS, NHLBI tabulation).
- In 2010, ≈67% of PCI procedures were performed on men, and ≈51% were performed on people ≥65 years of age (NHDS, NHLBI tabulation).
- In-hospital death rates for PCI have remained stable, although comorbidities increased for patients who received the procedure.[1]
- In 2010, ≈75% of stents implanted during PCI were DES compared with 25% that were bare-metal stents (NHDS, NHLBI computation).
- In a study of nontransferred patients with STEMI treated with primary PCI from July 2006 to March 2008, there was significant improvement over time in the percentage of patients receiving PCI within 90 minutes, from 54.1% from July to September 2006 to 74.1% from January to March 2008, among hospitals participating in the GWTG-CAD program. This improvement was seen whether or not hospitals joined the Door-to-Balloon Alliance during that period.[4]
- The rate of any cardiac stent procedure rose by 61% from 1999 to 2006, then declined by 27% between 2006 and 2009.[5]

Cardiac Open Heart Surgery

- The NHDS (NCHS) estimates that in 2010, in the United States, 219 000 patients underwent a total of 397 000 coronary artery bypass procedures (defined by procedure codes). CABG volumes have declined nationally since 1998. Risk-adjusted mortality for CABG has declined significantly over the past decade.
- Data from the STS Adult Cardiac Surgery Database, which voluntarily collects data from ≈80% of all hospitals that perform CABG in the United States, indicate that a total of 144 940 procedures involved CABG in 2014.[6]

Congenital Heart Surgery, 2010 to 2014 (From STS)

- Data from the STS Congenital Heart Surgery Database indicate that there were 112 114 procedures performed from July 2010 to June 2014. The in-hospital mortality

rate was 3.4% during that time period. The 5 most common diagnoses were the following: HLHS (6.5%); VSD, type 2 (6.3%); thoracic and/or mediastinal, other (6.1%); patent ductus arteriosus (5.4%); and ASD, secundum (3.9%).[7]

- The 5 most common primary procedures were delayed sternal closure (6.9%); VSD repair, patch (6.3%); mediastinal exploration (3.6%); ASD repair, patch (3.3%); and Norwood procedure (2.7%).

Heart Transplantations (Organ Procurement and Transplantation Network, April 23, 2015)

(See Charts 24-3 and 24-4.)

- In 2014, 2655 heart transplantations were performed in the United States (Chart 24-3). There are 249 transplant hospitals in the United States, 130 of which performed heart transplantations (based on Organ Procurement and Transplantation Network data as of April 23, 2015).
- Of the recipients in 2014, 71.0% were male, and 64.4% were white; 21.1% were black, whereas 9.5% were Hispanic. Heart transplantations by recipient age are shown in Chart 24-4.
- For transplants that occurred between 2009 and 2010, the 1-year survival rate was 90.8% for males and 90.6% for females; the 5-year rates between 2005 and 2010 were 77.5% for males and 75.6% for females. The 1- and 5-year survival rates for white cardiac transplant patients were 91.2% and 79.1%, respectively. For black patients, they were 88.3% and 68.6%, respectively. For Hispanic patients, they were 91.9% and 76.3%, respectively. For Asian patients, they were 89.9% and 81.2%, respectively.
- As of July 20, 2015, 4143 patients were on the transplant waiting list for a heart transplant, and 45 patients were on the list for a heart/lung transplant.

Table 24-1. 2012 National HCUP Statistics: Mean Hospital Charges, In-Hospital Death Rates, and Mean Length of Stay for Various Cardiovascular Procedures

Procedure	Mean Hospital Charges, $	In-Hospital Death Rate, %	Mean Length of Stay, d	*ICD-9-CM* Procedure Codes
Total vascular and cardiac surgery and procedures	78897	2.93	6.1	35–39, 00.50–00.51, 00.53–00.55, 00.61–00.66
Cardiac revascularization (bypass)	149480	1.44	9.2	36.1–36.3
PCI	70027	1.31	3.2	00.66
Cardiac catheterization	47862	1.04	3.9	37.21–37.23
Pacemakers	74515	1.24	5.1	37.7–37.8, 00.50, 00.53
Implantable defibrillators	152384	0.43	5.4	37.94–37.99, 00.51, 00.54
Endarterectomy	38847	0.32	2.6	38.12
Valves	190194	3.40	11.0	35.1–35.2, 35.99
Heart transplantations	676328	6.54	39.8	37.51

HCUP indicates Healthcare Cost and Utilization Project; *ICD-9-CM, International Classification of Diseases, Clinical Modification, 9th Revision*; and PCI, percutaneous coronary intervention.

Data derived from the Agency for Healthcare Research and Quality, HCUP Nationwide Inpatient Sample, 2012.

Table 24-2. Estimated* Inpatient Cardiovascular Operations, Procedures, and Patient Data by Sex and Age: United States, 2010 (in Thousands)

Operation/Procedure/ Patients	*ICD-9-CM* Procedure Codes	All	Sex		Age, y			
			Male	Female	<15	15–44	45–64	≥65
Valves	35.1, 35.2, 35.99	106	64	42	4†	5†	32	65
Angioplasty	36.0, 0.66	955	642	313	…	44	421	489
PCI (patients)	36.06, 36.07, 0.66	492	330	162	…	23	216	253
PCI	0.66	500	334	166	…	23	220	257
PCI with stents	36.06, 36.07	454	308	146	…	21	201	233
Cardiac revascularization‡	36.1–36.3	397	298	99	…	9†	157	231
Cardiac revascularization (patients)	36.1–36.3	219	164	55	…	5†	86	128
Cardiac catheterization	37.21–37.23	1029	638	391	7†	64	456	502
Pacemakers	37.7, 37.8, 00.50, 00.53	370	196	174	3†	6†	57	305
Pacemaker devices	37.8, 00.53	159	81	78	1†	3†	20	135
Pacemaker leads	37.7, 00.50	212	115	96	1†	3†	36	171
Implantable defibrillators	37.94–37.99, 00.51, 00.54	97	71	26	…	8†	31	58
Endarterectomy	38.12	100	55	45	…	…	29	71
Total vascular and cardiac surgery and procedures§‖	35–39, 00.50–00.51, 00.53– 00.55, 00.61–00.66	7588	4397	3191	310	681	2706	3891

These data do not reflect any procedures performed on an outpatient basis. Many more procedures are being performed on an outpatient basis. Some of the lower numbers in this table compared with 2006 probably reflect this trend. Data include procedures performed on newborn infants. Ellipses (…) indicate data not available; *ICD-9-CM, International Classification of Diseases, Clinical Modification, 9th Revision*; and PCI, percutaneous coronary intervention.

*Breakdowns are not available for some procedures, so entries for some categories do not add to totals. These data include codes for which the estimated number of procedures is <5000. Categories with such small numbers are considered unreliable by the National Center for Health Statistics and in some cases may have been omitted.

†Estimate should be used with caution because it may be unreliable or does not meet standards of reliability or precision.

‡Because ≥1 procedure codes are required to describe the specific bypass procedure performed, it is impossible from these (mixed) data to determine the average number of grafts per patient.

§Totals include procedures not shown here.

‖This estimate includes angioplasty and stent insertions for noncoronary arteries.

Data derived from the National Hospital Discharge Survey/National Center for Health Statistics, 2010. Estimates are based on a sample of inpatient records from short-stay hospitals in the United States.

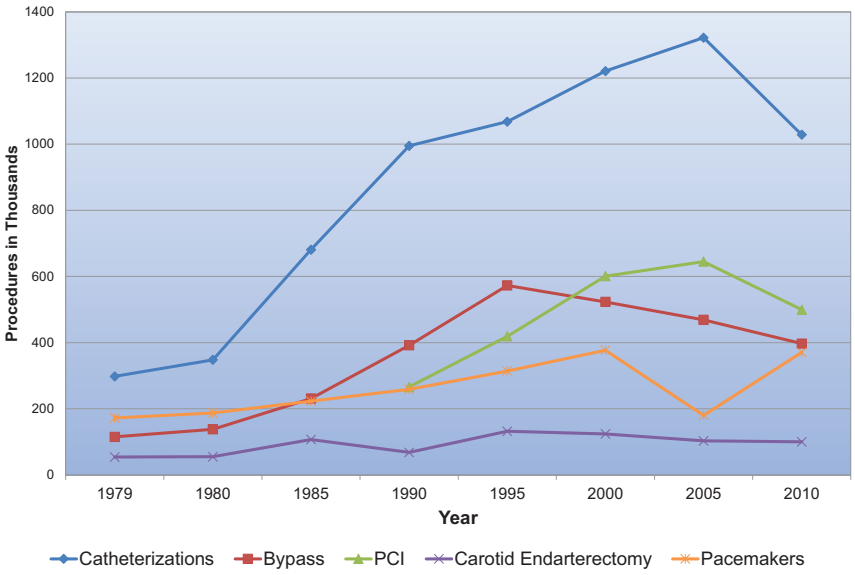

Chart 24-1. Trends in cardiovascular procedures, United States: 1979 to 2010; inpatient procedures only. PCI indicates percutaneous coronary intervention. Source: National Hospital Discharge Survey, National Center for Health Statistics, and National Heart, Lung, and Blood Institute.

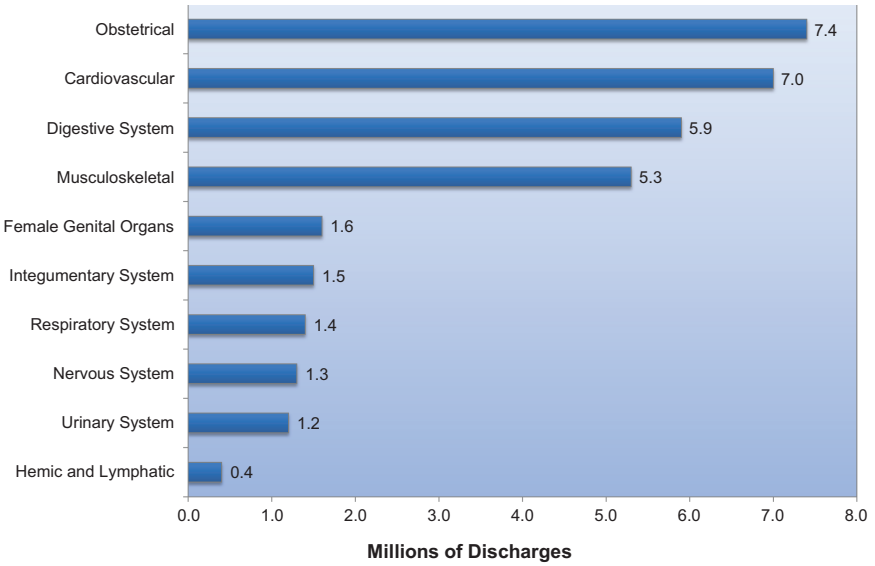

Chart 24-2. Number of surgical procedures in the 10 leading diagnostic groups, United States: 2010. Source: National Hospital Discharge Survey/National Center for Health Statistics and National Heart, Lung, and Blood Institute.

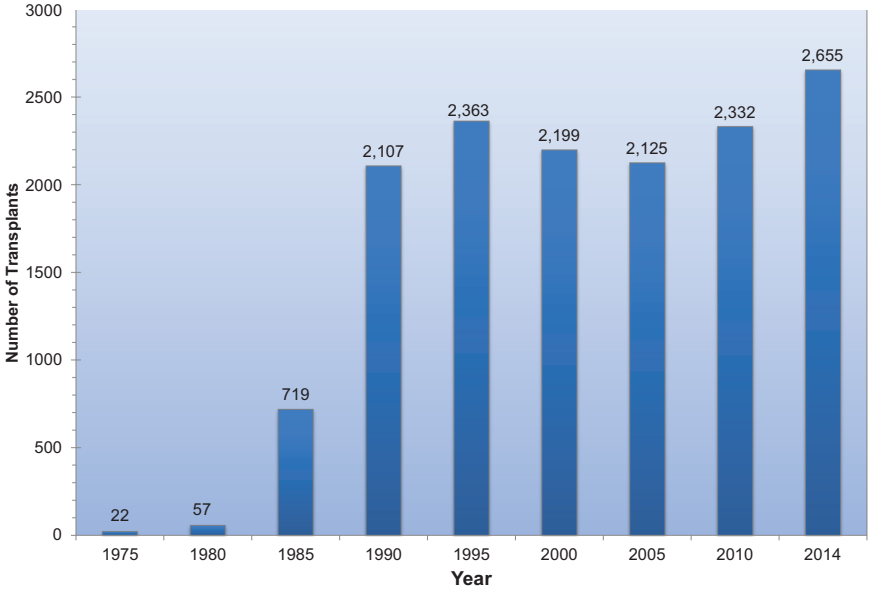

Chart 24-3. Trends in heart transplantations, 1975 to 2014. Source: Organ Procurement and Transplantation Network data as of April 17, 2015.

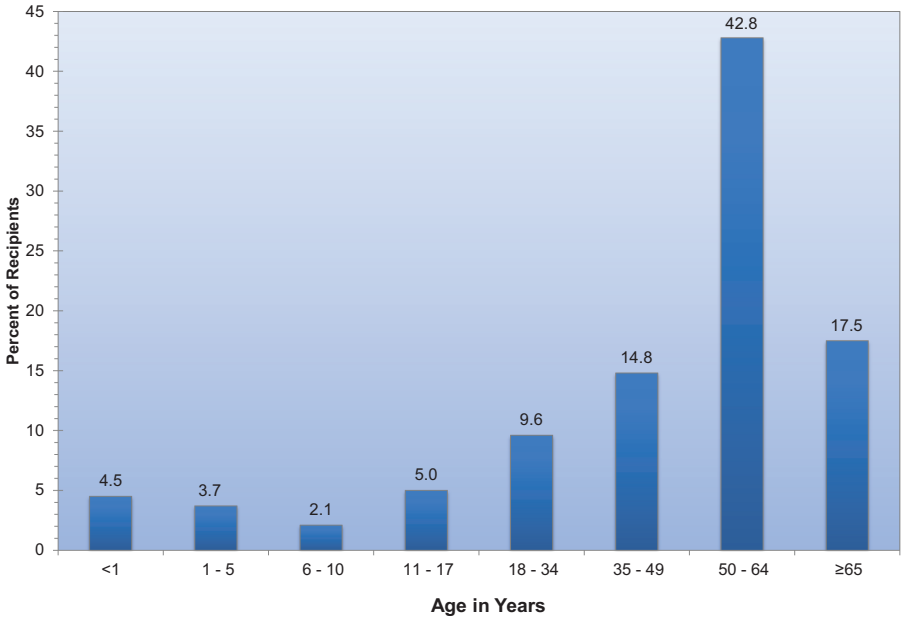

Chart 24-4. Heart transplantations in the United States by recipient age, 2014. Source: Organ Procurement and Transplantation Network data as of April 17, 2015.

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25. Economic Cost of Cardiovascular Disease

See Tables 25-1 and 25-2 and Charts 25-1 through 25-5.

The annual direct and indirect cost of CVD and stroke in the United States is an estimated $316.6 billion (Table 25-1; Chart 25-1). This figure includes $193.1 billion in expenditures (direct costs, which include the cost of physicians and other professionals, hospital services, prescribed medication, and home health care, but not the cost of nursing home care) and $123.5 billion in lost future productivity attributed to premature CVD and stroke mortality in 2011 to 2012 (indirect costs).

The direct costs for CVD and stroke are the healthcare expenditures for 2011 to 2012 (average annual) available on the Web site of the nationally representative MEPS of the AHRQ.[1] Details on the advantages or disadvantages of using MEPS data are provided in the "Heart Disease and Stroke Statistics–2011 Update."[2] Indirect mortality costs are estimated for 2011 to 2012 (average annual) by multiplying the number of deaths for those years attributable to CVD and strokes, in age and sex groups, by estimates of the present value of lifetime earnings for those age and sex groups as of 2011 to 2012. Mortality data are from the National Vital Statistics System of the NCHS.[3] The present values of lifetime earnings are unpublished estimates furnished by the Institute for Health and Aging, University of California, San Francisco, by Wendy Max, PhD, on April 29, 2015. Those estimates have a 3% discount rate, which is the recommended percentage.[4] The discount rate removes the effect of inflation in income over the lifetime of earnings. The estimates are for 2010, inflated to 2011 and 2012 to account for the 2010 to 2011 and 2012 change in hourly worker compensation in the business sector reported by the US Bureau of Labor Statistics.[5]

The indirect costs exclude lost productivity costs attributable to CVD and stroke illness during 2011 to 2012 among workers, people keeping house, people in institutions, and people unable to work. Those morbidity costs were substantial in very old studies, but an adequate update could not be made.

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Abbreviations Used in Chapter 25

AHA	American Heart Association
AHRQ	Agency for Healthcare Research and Quality
CHD	coronary heart disease
CHF	congestive heart failure
COPD	chronic obstructive pulmonary disease
CVD	cardiovascular disease
GI	gastrointestinal (tract)
HBP	high blood pressure
HD	heart disease
HF	heart failure
MEPS	Medical Expenditure Panel Survey
NCHS	National Center for Health Statistics

Most Costly Diseases

(See Table 25-2 and Chart 25-2.)

- CVD and stroke accounted for 15% of total health expenditures in 2011 to 2012, more than any major diagnostic group.[1] That is also the case for indirect mortality costs. By way of comparison, CVD total direct costs shown in Table 25-1 are higher than the 2011 AHRQ estimates for cancer, which were $88.7 billion (50% for outpatient or doctor office visits, 35% for inpatient care, and 11% for prescription drugs).[6]
- Table 25-2 shows direct and indirect costs for CVD by sex and by 2 broad age groups. Chart 25-2 shows total direct costs for the 23 leading chronic diseases in the MEPS list. HD is the most costly condition.[1]

Projections

(See Charts 25-3 through 25-5.)

The AHA developed methodology to project future costs of care for HBP, CHD, HF, stroke, and all other CVD.[7]

- By 2030, 43.9% of the US population is projected to have some form of CVD.
- Between 2012 and 2030, total direct medical costs of CVD are projected to increase from $396 billion to $918 billion (2012 $ in billions). Of this total, 60.5% is attributable to hospital costs, 15.6% to medications, 10.8% to physicians, 6.8% to nursing home care, 5.3% to home health care, and 1.1% to other costs.
- Indirect costs (attributable to lost productivity) for all CVDs are estimated to increase from $183 billion in 2012 to $290 billion in 2030 (2012 $ in billions), an increase of 58%.
- These data indicate that CVD prevalence and costs are projected to increase substantially.

Table 25-1. Estimated Direct and Indirect Costs (in Billions of Dollars) of CVD and Stroke: United States, Average Annual 2011 to 2012

	Heart Disease*	Stroke	Hypertensive Disease†	Other Circulatory Conditions	Total CVD
Direct costs‡					
Hospital inpatient stays	63.4	8.5	6.2	12.0	90.1
Hospital emergency department visits	4.7	0.9	1.4	0.6	7.6
Hospital outpatient or office-based provider visits	21.2	1.6	13.4	6.2	42.4
Home health care	8.8	4.8	5.0	1.6	20.2
Prescribed medicines	10.6	1.4	19.0	1.8	32.8
Total expenditures	108.7	17.2	45.0	22.2	193.1
Indirect costs§					
Lost productivity/mortality‖	98.6	15.8	3.6	5.5	123.5
Grand totals	207.3	33.0	48.6	27.7	316.6

Numbers do not add to total because of rounding. CVD indicates cardiovascular disease.

*This category includes coronary heart disease, heart failure, part of hypertensive disease, cardiac dysrhythmias, rheumatic heart disease, cardiomyopathy, pulmonary heart disease, and other or ill-defined heart diseases.

†Costs attributable to hypertensive disease are limited to hypertension without heart disease.

‡Medical Expenditure Panel Survey healthcare expenditures are estimates of direct payments for care of a patient with the given disease provided during the year, including out-of-pocket payments and payments by private insurance, Medicaid, Medicare, and other sources. Payments for over-the-counter drugs are not included. These estimates of direct costs do not include payments attributed to comorbidities. Total CVD costs are the sum of costs for the 4 diseases but with some duplication.

§The American Heart Association Statistics Committee agreed to suspend the presentation of estimates of lost productivity attributable to morbidity until a better estimating method can be developed.

‖Lost future earnings of people who died in 2011 and 2012, discounted at 3%.

Sources: Estimates from the Household Component of the Medical Expenditure Panel Survey of the Agency for Healthcare Research and Quality for direct costs (average annual 2011–2012).[1] Indirect mortality costs are based on 2011 and 2012 counts of deaths by the National Center for Health Statistics and an estimated present value of lifetime earnings furnished for 2010 by Dr Wendy Max (Institute for Health and Aging, University of California, San Francisco, April 29, 2015) and inflated to 2011 and 2012 from change in worker compensation reported by the US Bureau of Labor Statistics.

All estimates prepared by Michael Mussolino, National Heart, Lung, and Blood Institute.

Table 25-2. Costs of Total CVD in Billions of Dollars by Age and Sex: United States, Average Annual 2011 to 2012

	Total	Male	Female	Age <65 y	Age >65 y
Direct	193.1	99.0	94.1	93.7	99.4
Indirect mortality	123.5	91.8	31.7	106.0	17.5
Total	316.6	190.8	125.8	199.7	116.9

Numbers may not add to total because of rounding. CVD indicates cardiovascular diseases and stroke.

Source: Medical Expenditure Panel Survey, average annual 2011 to 2012 (direct costs) and mortality data from the National Center for Health Statistics and present value of lifetime earnings from the Institute for Health and Aging, University of California, San Francisco (indirect costs).

All estimates prepared by Michael Mussolino, National Heart, Lung, and Blood Institute.

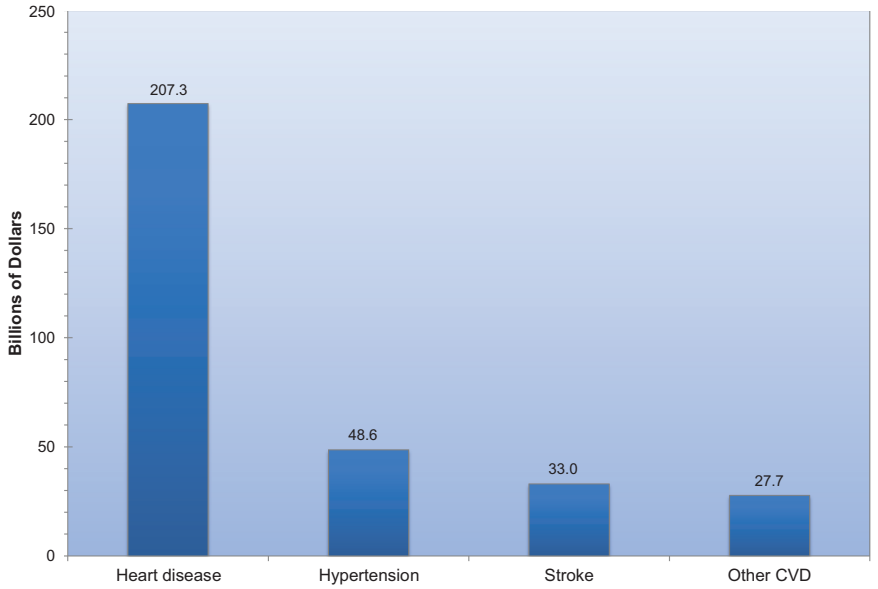

Chart 25-1. Direct and indirect costs of cardiovascular disease (CVD) and stroke (in billions of dollars), United States, average annual 2011 to 2012. Source: Prepared by the National Heart, Lung, and Blood Institute.[1–4]

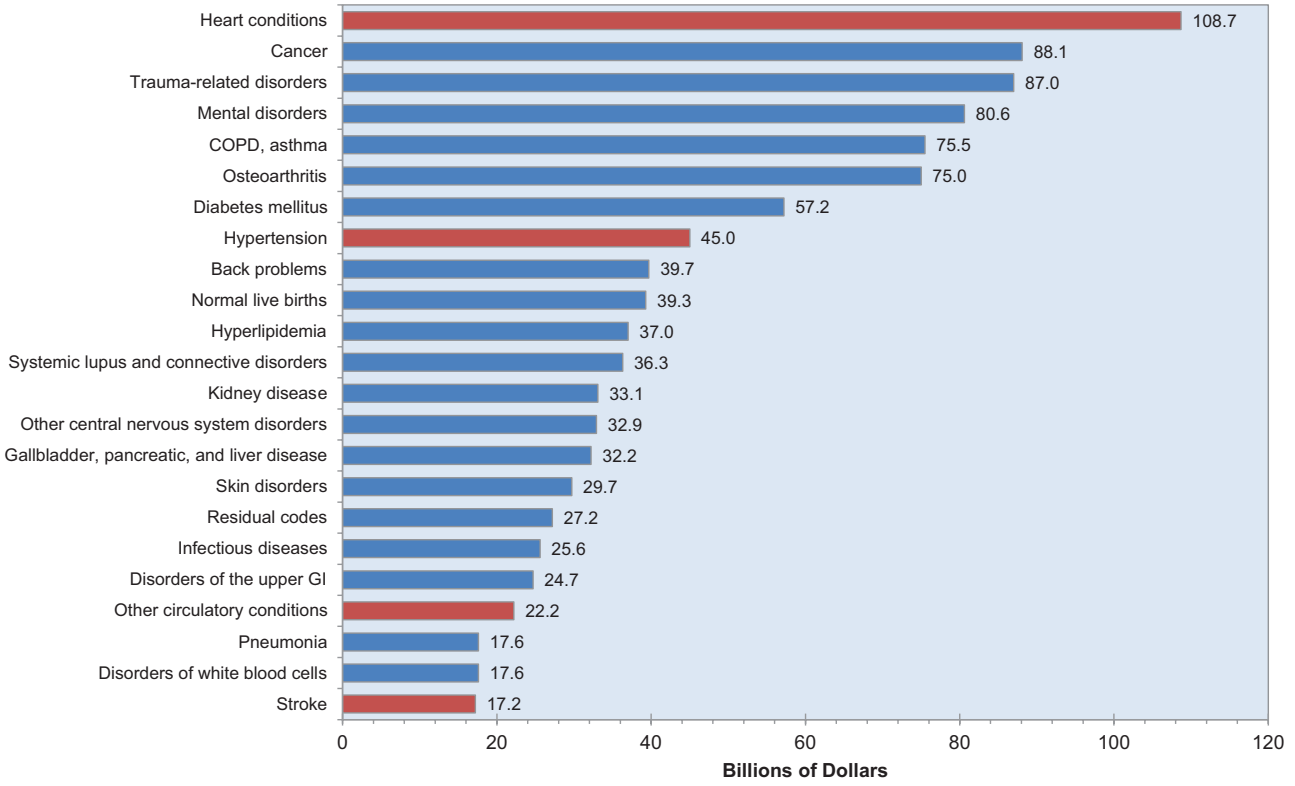

Chart 25-2. The 23 leading diagnoses for direct health expenditures, United States, average annual 2011 to 2012 (in billions of dollars). COPD indicates chronic obstructive pulmonary disease; and GI, gastrointestinal (tract). Source: National Heart, Lung, and Blood Institute; estimates are from the Medical Expenditure Panel Survey, Agency for Healthcare Research and Quality, and exclude nursing home costs.

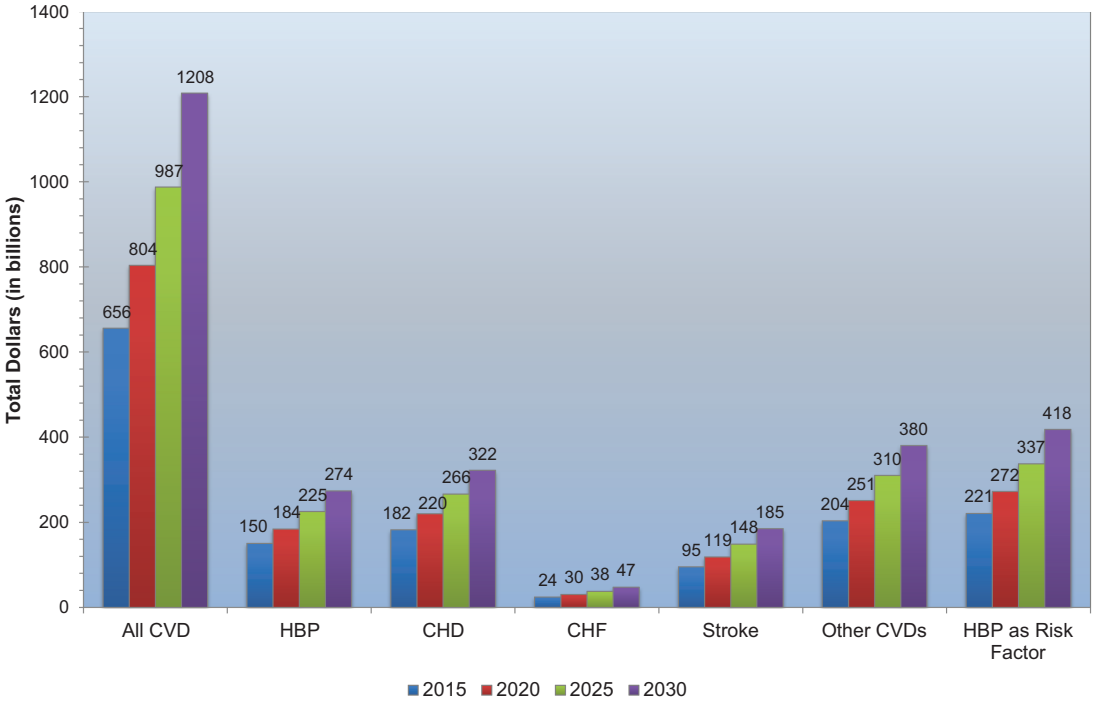

Chart 25-3. Projected total costs of cardiovascular disease (CVD), 2015 to 2030 (2012 $ in billions) in the United States. CHD indicates coronary heart disease; CHF, congestive heart failure; and HBP, high blood pressure. Unpublished data tabulated by the American Heart Association using methods described in Heidenreich et al.[7]

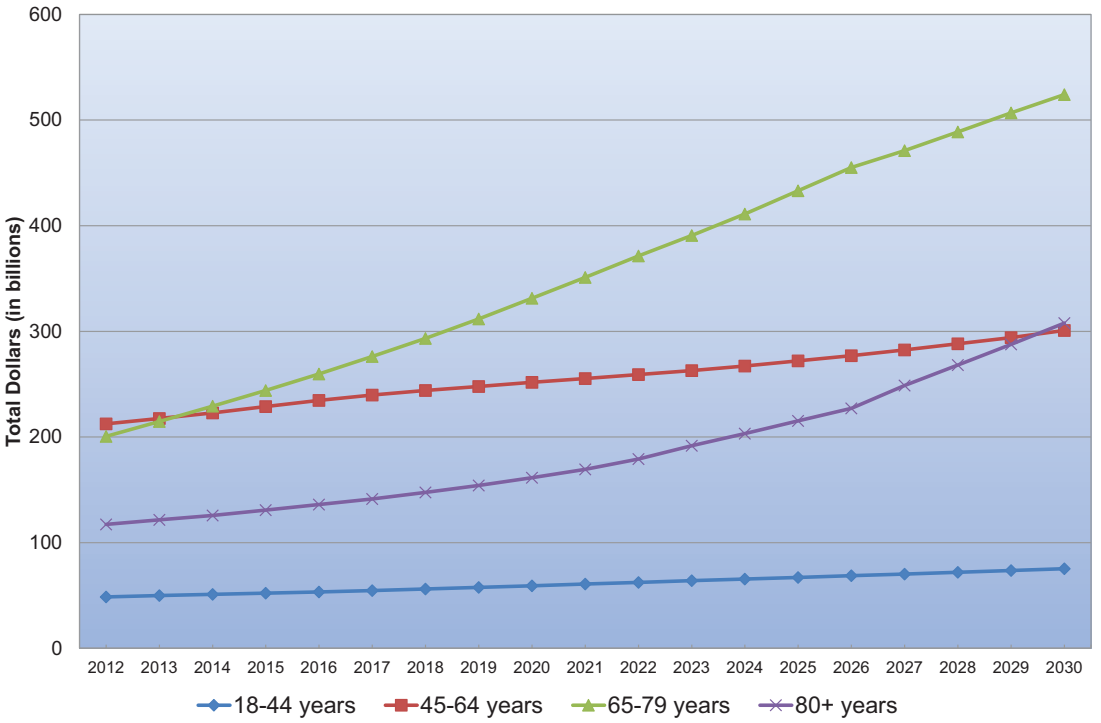

Chart 25-4. Projected total (direct and indirect) costs of total cardiovascular disease by age (2012 $ in billions). Unpublished data tabulated by the American Heart Association using methods described in Heidenreich et al.[7]

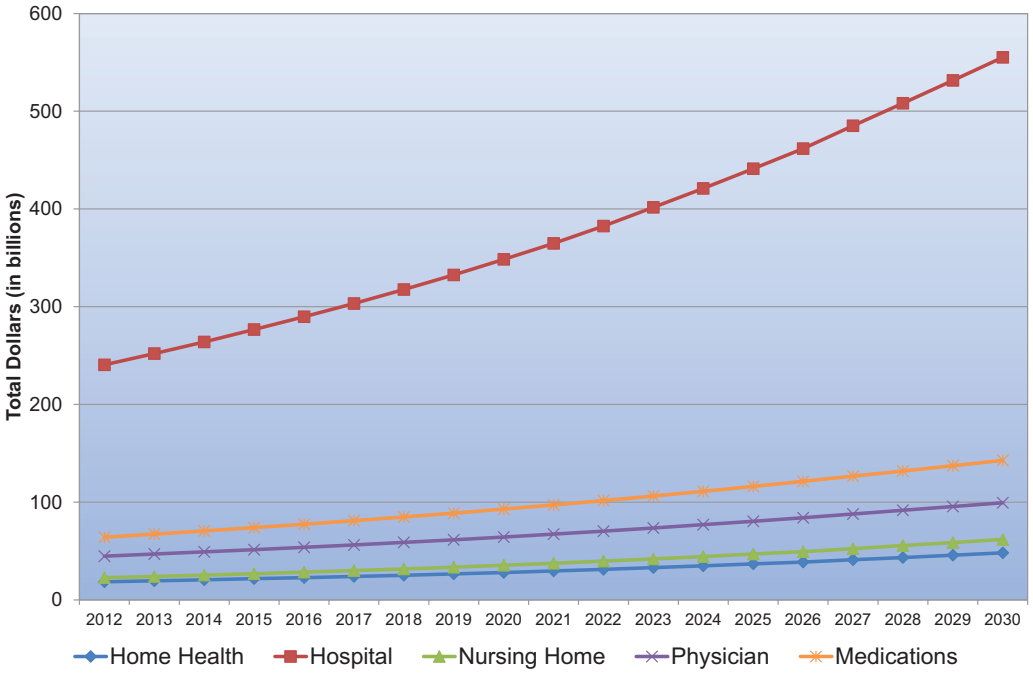

Chart 25-5. Projected direct costs of total cardiovascular disease by type of cost (2010 $ in billions). Unpublished data tabulated by the American Heart Association using methods described in Heidenreich et al.[7]

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26. At-a-Glance Summary Tables

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See Tables 26-1 through 26-3.

Sources: See the following summary tables and charts for complete details:

- Smoking—Table 3-1
- Physical activity —Table 4-1
- Overweight/obesity—Table 6-1; Chart 6-1
- Blood cholesterol—Table 8-1
- High blood pressure—Table 9-1
- Diabetes mellitus—Table 10-1
- Total cardiovascular diseases—Table 13-1
- Stroke—Table 14-1
- Congenital heart defects—Table 15-1
- Coronary heart disease—Table 19-1
- Heart failure—Table 20-1

Table 26-1. Males and CVD: At-a-Glance Table

Diseases and Risk Factors	Both Sexes	Total Males	NH White Males	NH Black Males	Hispanic Males	NH Asian Males	NH American Indian/ Alaska Native Males
Smoking							
Prevalence, 2014*	43.9 M (16.9%)	24.3 M (18.8%)	19.9%	21.4%	13.8%	13.8%	18.6%
PA†							
Prevalence, 2014, %*	21.4%	25.4%	23.6%‡	20.0%‡	15.3%‡	17.0%‡	24.0%‡
Overweight and obesity							
Prevalence, 2012							
Overweight and obesity, BMI >25.0 kg/m²§	159.2 M (68.5%)	81.5 M (72.5%)	72.7%	69.4%	80.1%	…	…
Obesity, BMI >30.0 kg/m²§	81.8 M (35.2%)	38.6 M (34.4%)	34.2%	37.9%	38.4%	11.0%*‡	42.3%*‡
Blood cholesterol							
Prevalence, 2012							
Total cholesterol >200 mg/dL§	100.1 M (42.8%)	45.3 M (40.4%)	39.9%	37.4%	46.2%	…	…
Total cholesterol >240 mg/dL§	30.9 M (13.1%)	13.0 M (11.6%)	11.5%	8.8%	14.8%	…	…
LDL-C >130 mg/dL§	73.5 M (31.7%)	34.9 M (31.0%)	29.4%	30.7%	38.8%	…	…
HDL-C <40 mg/dL§	44.6 M (19.9%)	32.4 M (28.9%)	28.7%	20.0%	33.8%	…	…
HBP							
Prevalence, 2012§	80.0 M (32.6%)	38.3 M (33.5%)	32.9%	44.9%	29.6%	…	26.4%*‡
Mortality, 2013‖	71 942	33 563	22 392	7344	2546	1875‡	420‡
DM							
Prevalence, 2012							
Physician-diagnosed DM§	21.1 M (8.5%)	10.5 M (9.0%)	7.6%	13.8%	12.5%	…	…
Undiagnosed DM§	8.1 M (3.3%)	5.1 M (4.4%)	4.0%	4.8%	6.8%	…	…
Prediabetes§	80.8 M (35.3%)	46.4 M (42.4%)	43.0%	36.3%	43.0%	…	…
Incidence, diagnosed DM§	1.7 M	…	…	…	…	…	…
Mortality, 2013‖	75 578	39 841	27 807	6298	3934	2271‡	922‡
Total CVD							
Prevalence, 2012§	85.6 M (35.0%)	41.8 M (36.4%)	36.1%	46.0%	32.4%	…	…
Mortality, 2013‖¶	800 937	402 851	317 499	48 098	23 892	18 819‡	3895‡
Stroke							
Prevalence, 2012§	6.6 M (2.6%)	3.0 M (2.6%)	2.2%	4.2%	2.8%	…	3.0%*‡
New and recurrent strokes‖	795.0 K	370.0 K	325.0 K	45.0 K	…	…	…
Mortality, 2013‖	128 978	53 691	40 350	7266	3841	4147‡	569‡
CHD							
Prevalence, CHD, 2012§	15.5 M (6.2%)	8.9 M (7.6%)	7.8%	7.2%	6.7%	…	6.0%*‡
Prevalence, MI, 2012§	7.6 M (2.8%)	4.9 M (4.0%)	4.1%	3.4%	3.5%	…	…
Prevalence, AP, 2012§	8.2 M (3.3%)	4.0 M (3.4%)	3.4%	3.3%	3.2%	…	…
New and recurrent MI and Fatal CHD#**	965.0 K	560.0 K	480.0 K	80.0 K	…	…	…
New and recurrent MI#**	750.0 K	440.0 K	…	…	…	…	…
Incidence, AP (stable angina)††	565.0 K	370.0 K	…	…	…	…	…
Mortality, 2013, CHD‖	370 213	208 515	168 228	20 758	12 518	8477‡	1949‡
Mortality, 2013, MI‖	116 793	66 051	53 434	6456	4099	2616‡	589‡
HF							
Prevalence, 2012§	5.7 M (2.2%)	2.7 M (2.3%)	2.2%	2.8%	2.1%	…	…
Incidence, 2012#‡‡	915.0 K	440.0 K	385.0 K	55.0 K	…	…	…
Mortality, 2013‖	65 120	28 513	23 847	2933	1144	954‡	230‡

AP indicates angina pectoris (chest pain); BMI, body mass index; CHD, coronary heart disease (includes heart attack, AP chest pain, or both); CVD, cardiovascular disease; DM, diabetes mellitus; ellipses (…), data not available; HBP, high blood pressure; HDL-C, high-density lipoprotein cholesterol; HF, heart failure; K, thousands; LDL-C, low-density lipoprotein cholesterol; M, millions; MI, myocardial infarction (heart attack); NH, non-Hispanic; and PA, physical activity.

*Age ≥18 years (National Health Interview Survey, 2014).

†Met 2008 full federal PA guidelines for adults.

‡Both sexes (National Health Interview Survey, 2014).

§Age ≥20 years.

‖All ages.

¶Total CVD mortality includes deaths of congenital heart disease.

#Estimates include Hispanics and non-Hispanics. Estimates for whites include other nonblack races.

**Age ≥35 years.

††Age ≥45 years.

‡‡Age ≥55 years.

Table 26-2. Females and CVD: At-a-Glance Table

Diseases and Risk Factors	Both Sexes	Total Females	NH White Females	NH Black Females	Hispanic Females	NH Asian Females	NH American Indian/Alaska Native Females
Smoking							
Prevalence, 2014*	43.9 M (16.9%)	19.5 M (15.1%)	18.3%	13.4%	7.4%	5.5%	21.6%
PA†							
Prevalence, 2014, %*	21.4%	17.6%	23.6%‡	20.0%‡	15.3%‡	17.0%‡	24.0%‡
Overweight and obesity							
Prevalence, 2012							
Overweight and obesity, BMI >25.0 kg/m^2§	159.2 M (68.5%)	77.7 M (64.7%)	61.2%	81.9%	76.3%	…	…
Obesity, BMI >30.0 kg/m^2§	81.8 M (35.2%)	43.2 M (36.0%)	32.5%	57.5%	42.9%	11.0%*‡	42.3%*‡
Blood cholesterol							
Prevalence, 2012							
Total cholesterol >200 mg/dL§	100.1 M (42.8%)	54.8 M (44.9%)	45.9%	40.7%	43.4%	…	…
Total cholesterol >240 mg/dL§	30.9 M (13.1%)	17.9 M (14.4%)	15.3%	10.9%	13.7%	…	…
LDL-C >130 mg/dL§	73.5 M (31.7%)	38.6 M (32.0%)	32.0%	33.6%	31.8%	…	…
HDL-C <40 mg/dL§	44.6 M (19.9%)	12.2 M (10.4%)	10.2%	10.3%	12.8%	…	…
HBP							
Prevalence, 2012§	80.0 M (32.6%)	41.7 M (31.7%)	30.1%	46.1%	29.9%	…	26.4%*‡
Mortality, 2013‖	71 942	38 379	27 446	7230	2362	1875‡	420‡
DM							
Prevalence, 2012							
Physician-diagnosed DM§	21.1 M (8.5%)	10.6 M (8.0%)	6.1%	14.6%	11.8%	…	…
Undiagnosed DM§	8.1 M (3.3%)	3.0 M (2.4%)	1.7%	2.3%	5.0%	…	…
Prediabetes§	80.8 M (35.3%)	34.4 M (28.4%)	28.9%	27.8%	26.0%	…	…
Incidence, diagnosed DM§	1.7 M	…	…	…	…	…	…
Mortality, 2013‖	75 578	35 737	23 490	6941	3698	2271‡	922‡
Total CVD							
Prevalence, 2012§	85.6 M (35.0%)	43.8 M (33.7%)	31.9%	48.3%	32.5%	…	…
Mortality, 2013‖¶	800 937	398 086	317 321	48 138	20 976	18 819‡	3895‡
Stroke							
Prevalence, 2012§	6.6 M (2.6%)	3.6 M (2.7%)	2.5%	4.7%	2.0%	…	3.0%*‡
New and recurrent strokes‖	795.0 K	425.0 K	365.0 K	60.0 K	…	…	…
Mortality, 2013‖	128 978	75 287	59 409	8845	4286	4147‡	569‡
CHD							
Prevalence, CHD, 2012§	15.5 M (6.2%)	6.6 M (5.0%)	4.6%	7.0%	5.9%	…	6.0%*‡
Prevalence, MI, 2012§	7.6 M (2.8%)	2.7 M (1.8%)	1.8%	2.2%	1.7%	…	…
Prevalence, AP, 2012§	8.2 M (3.3%)	4.2 M (3.2%)	2.9%	5.0%	3.8%	…	…
New and recurrent MI and fatal CHD#**	965.0 K	405.0 K	340.0 K	65.0 K	…	…	…
New and recurrent MI#**	750.0 K	310.0 K	…	…	…	…	…
Incidence, AP (stable angina)††	565.0 K	195.0 K	…	…	…	…	…
Mortality, 2013, CHD‖	370 213	161 698	129 273	18 441	9270	8477‡	1949‡
Mortality, 2013, MI‖	116 793	50 742	40 461	6004	2858	2616‡	589‡
HF							
Prevalence, 2012§	5.7 M (2.2%)	3.0 M (2.2%)	2.2%	3.2%	2.1%	…	…
Incidence, 2012#‡‡	915.0 K	475.0 K	405.0 K	70.0 K	…	…	…
Mortality, 2013‖	65 120	36 607	30 940	3585	1400	954‡	230‡

AP indicates angina pectoris (chest pain); BMI, body mass index; CHD, coronary heart disease (includes heart attack, AP chest pain, or both); CVD, cardiovascular disease; DM, diabetes mellitus; ellipses (…), data not available; HBP, high blood pressure; HDL-C, high-density lipoprotein cholesterol; HF, heart failure; K, thousands; LDL-C, low-density lipoprotein cholesterol; M, millions; MI, myocardial infarction (heart attack); NH, non-Hispanic; and PA, physical activity.

*Age ≥18 years (National Health Interview Survey, 2014).

†Met 2008 full federal PA guidelines for adults.

‡Both sexes (National Health Interview Survey, 2014).

§Age ≥20 years.

‖All ages.

¶Total CVD mortality includes deaths of congenital heart disease.

#Estimates include Hispanics and non-Hispanics. Estimates for whites include other nonblack races.

**Age ≥35 years.

††Age ≥45 years.

‡‡Age ≥55 years.

Table 26-3. Children, Youth, and CVD: At-a-Glance Table

				NH Whites		NH Blacks		Hispanic	
Diseases and Risk Factors	Both Sexes	Total Males	Total Females	Males	Females	Males	Females	Males	Females
Smoking, %									
Prevalence, ages 12–17 y, 2013*									
Current cigarette smoking, 2013	5.6%	5.7%	5.5%	7.2%		3.2%		3.7%	
Current cigar smoking, 2013	2.3%	3.2%	1.4%	…		…		…	
Current smokeless tobacco use, 2013	2.0%	3.4%	0.4%	…		…		…	
PA, †									
Prevalence, grades 9–12, 2013									
Met currently recommended levels of PA‡	27.1%	36.6%	17.7%	37.5%	18.7%	37.2%	16.0%	33.9%	17.4%
Overweight and obesity									
Prevalence, 2012§									
Children and adolescents, aged 2–19 y, overweight or obese	23.7 M (31.8%)	12.2 M (32.0%)	11.5 M (31.6%)	27.8%	29.2%	34.4%	36.1%	40.7%	37.0%
Children and adolescents, aged 2–19 y, obese	12.6 M (16.9%)	6.3 M (16.7%)	6.3 M (17.2%)	12.6%	15.6%	19.9%	20.5%	24.1%	20.6%
Blood cholesterol, mg/dL, 2012									
Mean total cholesterol									
Ages 6–11 y	160.2	160.5	159.8	158.6	158.2	163.7	159.8	160.5	161.2
Ages 12–19 y	158.3	155.2	161.6	155.2	163.2	153.9	158.6	157.0	160.4
Mean HDL-C									
Ages 6–11 y	53.9	55.4	52.4	55.1	52.5	58.5	54.5	53.5	51.4
Ages 12–19 y	51.4	49.4	53.4	48.9	52.4	52.6	55.1	48.1	53.6
Mean LDL-C									
Ages 12–19 y	89.3	88.3	90.3	89.5	91.1	86.7	90.9	87.4	88.9
Congenital cardiovascular defects									
Mortality, 2013‖	3051	1634	1417	973	869	268	234	299	253

"Overweight" indicates a body mass index in the 95th percentile of the Centers for Disease Control and Prevention 2000 growth chart. CVD indicates cardiovascular disease; ellipses (…), data not available; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; M, millions; NH, non-Hispanic; and PA, physical activity.

*National Survey on Drug Use and Health; respondents were asked, "During the past 30 days, have you smoked part or all of a cigarette?"

†Kann L, Kinchen S, Shanklin S, Flint KH, Hawkins J, Harris WA, Lowry R, Olsen EO, McManus T, Chyen D, Whittle L, Taylor E, Demissie Z, Brener ND, Thornton J, Moore J, Zaza S. Youth risk behavior surveillance: United States, 2013 [published correction appears in *MMWR Morb Wkly Rep*. 2014;63:576]. *MMWR Surveill Summ*. 2014;63(suppl 4):1–168.

‡Physically active at least 60 min/d on all 7 days.

§Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of childhood and adult obesity in the United States, 2011–2012. *JAMA*. 2014;311:806–814. doi: 10.1001/jama.2014.732.

‖All ages.

27. Glossary

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- *Age-adjusted rates*—Used mainly to compare the rates of ≥2 communities or population groups or the nation as a whole over time. The American Heart Association (AHA) uses a standard population (2000), so these rates are not affected by changes or differences in the age composition of the population. Unless otherwise noted, all death rates in this publication are age adjusted per 100 000 population and are based on underlying cause of death.
- *Agency for Healthcare Research and Quality (AHRQ)*—A part of the US Department of Health and Human Services, this is the lead agency charged with supporting research designed to improve the quality of health care, reduce the cost of health care, improve patient safety, decrease the number of medical errors, and broaden access to essential services. The AHRQ sponsors and conducts research that provides evidence-based information on healthcare outcomes, quality, cost, use, and access. The information helps healthcare decision makers (patients, clinicians, health system leaders, and policy makers) make more informed decisions and improve the quality of healthcare services. The AHRQ conducts the Medical Expenditure Panel Survey (MEPS; ongoing).
- *Bacterial endocarditis*—An infection of the heart's inner lining (endocardium) or of the heart valves. The bacteria that most often cause endocarditis are streptococci, staphylococci, and enterococci.
- *Body mass index (BMI)*—A mathematical formula to assess body weight relative to height. The measure correlates highly with body fat. It is calculated as weight in kilograms divided by the square of the height in meters (kg/m^2).
- *Centers for Disease Control and Prevention/National Center for Health Statistics (CDC/NCHS)*—CDC is an agency within the US Department of Health and Human Services. The CDC conducts the Behavioral Risk Factor Surveillance System (BRFSS), an ongoing survey. The CDC/NCHS conducts or has conducted these surveys (among others):
  - —National Health Examination Survey (NHES I, 1960–1962; NHES II, 1963–1965; NHES III, 1966–1970)
  - —National Health and Nutrition Examination Survey I (NHANES I; 1971–1975)
  - —National Health and Nutrition Examination Survey II (NHANES II; 1976–1980)
  - —National Health and Nutrition Examination Survey III (NHANES III; 1988–1994)
  - —National Health and Nutrition Examination Survey (NHANES; 1999 to …) (ongoing)
  - —National Health Interview Survey (NHIS; ongoing)
  - —National Hospital Discharge Survey (NHDS; 1965–2010)
  - —National Ambulatory Medical Care Survey (NAMCS; ongoing)
  - —National Hospital Ambulatory Medical Care Survey (NHAMCS; ongoing)
  - —National Nursing Home Survey (periodic)
  - —National Home and Hospice Care Survey (periodic)
  - —National Vital Statistics System (ongoing)
- *Centers for Medicare & Medicaid Services, formerly Health Care Financing Administration*—The federal agency that administers the Medicare, Medicaid, and Child Health Insurance programs.
- *Comparability ratio*—Provided by the NCHS to allow time-trend analysis from one *International Classification of Diseases* (*ICD*) revision to another. It compensates for the "shifting" of deaths from one causal code number to another. Its application to mortality based on one *ICD* revision means that mortality is "comparability modified" to be more comparable to mortality coded to the other *ICD* revision.
- *Coronary heart disease (CHD) (ICD-10 codes I20–I25)*—This category includes acute myocardial infarction (I21–I22), other acute ischemic (coronary) heart disease (I24), angina pectoris (I20), atherosclerotic cardiovascular disease (I25.0), and all other forms of chronic ischemic (coronary) heart disease (I25.1–I25.9).
- *Death rate*—The relative frequency with which death occurs within some specified interval of time in a population. National death rates are computed per 100 000 population. Dividing the total number of deaths by the total population gives a crude death rate for the total population. Rates calculated within specific subgroups, such as age-specific or sex-specific rates, are often more meaningful and informative. They allow well-defined subgroups of the total population to be examined. Unless otherwise stated, all death rates in this publication are age adjusted and are per 100 000 population.
- *Diseases of the circulatory system (ICD codes I00–I99)*—Included as part of what the AHA calls "cardiovascular disease" ("Total cardiovascular disease" in this Glossary).
- *Diseases of the heart*—Classification the NCHS uses in compiling the leading causes of death. Includes acute rheumatic fever/chronic rheumatic heart diseases (I00–I09), hypertensive heart disease (I11), hypertensive heart and renal disease (I13), CHD (I20–I25), pulmonary heart disease and diseases of pulmonary circulation (I26–I28), heart failure (I50), and other forms of heart disease (I29–I49, I50.1–I51). "Diseases of the heart" are not equivalent to "total cardiovascular disease," which the AHA prefers to use to describe the leading causes of death.
- *Health Care Financing Administration*—See Centers for Medicare & Medicaid Services.
- *Hispanic origin*—In US government statistics, "Hispanic" includes people who trace their ancestry to Mexico, Puerto Rico, Cuba, Spain, the Spanish-speaking countries of Central or South America, the Dominican Republic, or other Spanish cultures, regardless of race. It does not include people from Brazil, Guyana, Suriname, Trinidad, Belize, or Portugal, because Spanish is not the first language in those countries. Most of the data in this update are for Mexican Americans or Mexicans, as reported by government agencies or specific studies. In many cases, data for all Hispanics are more difficult to obtain.
- *Hospital discharges*—The number of inpatients (including newborn infants) discharged from short-stay hospitals for whom some type of disease was the first-listed diagnosis.

Discharges include those discharged alive, dead, or "status unknown."

- *International Classification of Diseases (ICD) codes*—A classification system in standard use in the United States. The *International Classification of Diseases* is published by the World Health Organization. This system is reviewed and revised approximately every 10 to 20 years to ensure its continued flexibility and feasibility. The 10th revision (*ICD-10*) began with the release of 1999 final mortality data. The *ICD* revisions can cause considerable change in the number of deaths reported for a given disease. The NCHS provides "comparability ratios" to compensate for the "shifting" of deaths from one *ICD* code to another. To compare the number or rate of deaths with that of an earlier year, the "comparability-modified" number or rate is used.
- *Incidence*—An estimate of the number of new cases of a disease that develop in a population, usually in a 1-year period. For some statistics, new and recurrent attacks, or cases, are combined. The incidence of a specific disease is estimated by multiplying the incidence rates reported in community- or hospital-based studies by the US population. The rates in this report change only when new data are available; they are not computed annually.
- *Major cardiovascular diseases*—Disease classification commonly reported by the NCHS; represents *ICD* codes I00 to I78. The AHA does not use "major cardiovascular diseases" for any calculations. See "Total cardiovascular disease" in this Glossary.
- *Metabolic syndrome*—Metabolic syndrome is defined* as the presence of any 3 of the following 5 diagnostic measures: Elevated waist circumference (≥102 cm in men or ≥88 cm in women), elevated triglycerides (≥150 mg/dL [1.7 mmol/L] or drug treatment for elevated triglycerides), reduced high-density lipoprotein cholesterol (<40 mg/dL [0.9 mmol/L] in men, <50 mg/dL [1.1 mmol/L] in women, or drug treatment for reduced high-density lipoprotein cholesterol), elevated blood pressure (≥130 mm Hg systolic blood pressure, ≥85 mm Hg diastolic blood pressure, or drug treatment for hypertension), and elevated fasting glucose (≥100 mg/dL or drug treatment for elevated glucose).
- *Morbidity*—Incidence and prevalence rates are both measures of morbidity (ie, measures of various effects of disease on a population).
- *Mortality*—Mortality data for states can be obtained from the NCHS Web site (http://cdc.gov/nchs/), by direct communication with the CDC/NCHS, or from the AHA on request. The total number of deaths attributable to a given disease in a population during a specific interval of time, usually 1 year, are reported. These data are compiled from death certificates and sent by state health agencies to the NCHS. The process of verifying and tabulating the data takes ≈2 years.
- *National Heart, Lung, and Blood Institute (NHLBI)*—An institute in the National Institutes of Health in the US Department of Health and Human Services. The NHLBI conducts such studies as the following:

  —Framingham Heart Study (FHS; 1948 to …) (ongoing)
  —Honolulu Heart Program (HHP; 1965–1997)
  —Cardiovascular Health Study (CHS; 1988 to …) (ongoing)
  —Atherosclerosis Risk in Communities (ARIC) study (1985 to …) (ongoing)
  —Strong Heart Study (SHS; 1989–1992, 1991–1998)
  —The NHLBI also published reports of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure and the Third Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III).

- *National Institute of Neurological Disorders and Stroke (NINDS)*—An institute in the National Institutes of Health of the US Department of Health and Human Services. The NINDS sponsors and conducts research studies such as these:

  —Greater Cincinnati/Northern Kentucky Stroke Study (GCNKSS)
  —Rochester (Minnesota) Stroke Epidemiology Project
  —Northern Manhattan Study (NOMAS)
  —Brain Attack Surveillance in Corpus Christi (BASIC) Project

- *Physical activity*—Any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a basal level.
- *Physical fitness*—The ability to perform daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuits and respond to emergencies. Physical fitness includes a number of components consisting of cardiorespiratory endurance (aerobic power), skeletal muscle endurance, skeletal muscle strength, skeletal muscle power, flexibility, balance, speed of movement, reaction time, and body composition.
- *Prevalence*—An estimate of the total number of cases of a disease existing in a population during a specified period. Prevalence is sometimes expressed as a percentage of population. Rates for specific diseases are calculated from periodic health examination surveys that government agencies conduct. Annual changes in prevalence as reported in this Statistical Update reflect changes in the population size. Changes in rates can be evaluated only by comparing prevalence rates estimated from surveys conducted in different years. Note: In the data tables, which are located in the different disease and risk factor chapters, if the percentages shown are age adjusted, they will not add to the total.
- *Race and Hispanic origin*—Race and Hispanic origin are reported separately on death certificates. In this publication, unless otherwise specified, deaths of people of Hispanic origin are included in the totals for whites, blacks, American Indians or Alaska Natives, and Asian or Pacific Islanders according to the race listed on the decedent's death certificate. Data for Hispanic people include all people of Hispanic origin of any race. See "Hispanic origin" in this Glossary.
- *Stroke (ICD-10 codes I60–I69)*—This category includes subarachnoid hemorrhage (I60); intracerebral hemorrhage (I61); other nontraumatic intracranial hemorrhage (I62); cerebral infarction (I63); stroke, not specified as hemorrhage or infarction (I64); occlusion and stenosis of precerebral arteries not resulting in cerebral infarction (I65); occlusion and stenosis of cerebral arteries not

*According to criteria established by the AHA/NHLBI and published in *Circulation* (*Circulation*. 2005;112:2735–2752).

resulting in cerebral infarction (I66); other cerebrovascular diseases (I67); cerebrovascular disorders in diseases classified elsewhere (I68); and sequelae of cerebrovascular disease (I69).

- *Total cardiovascular disease (ICD-10 codes I00–I99, Q20–Q28)*—This category includes rheumatic fever/rheumatic heart disease (I00–I09); hypertensive diseases (I10–I15); ischemic (coronary) heart disease (I20–I25); pulmonary heart disease and diseases of pulmonary circulation (I26–I28); other forms of heart disease (I30–I52); cerebrovascular disease (stroke) (I60–I69); atherosclerosis (I70); other diseases of arteries, arterioles, and capillaries (I71–I79); diseases of veins, lymphatics, and lymph nodes not classified elsewhere (I80–I89); and other and unspecified disorders of the circulatory system (I95–I99). When data are available, we include congenital cardiovascular defects (Q20–Q28).
- *Underlying cause of death or any-mention cause of death*—These terms are used by the NCHS when defining mortality. Underlying cause of death is defined by the World Health Organization as "the disease or injury which initiated the chain of events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury." Any-mention cause of death includes the underlying cause of death and up to 20 additional multiple causes listed on the death certificate.